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# STUDIES OF STRATOSPHERIC EDDY TRANSPORT.

I. The Observed Ozone Flux by the Transient Eddies, 0-30 km.

[redacted]

II. Eddy Diffusion Coefficients and Wind Statistics, 30-60 km.


(10) G. D. Nastrom, [redacted] D. E. Brown

R. W. Wilcox


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In Part I, ozonesonde data ~~have been~~ were matched with concomittant rawinsonde data to provide a direct determination of meridional flux of ozone by ~~the~~ transient eddies. Data are from about 25 stations in ~~the four regions:~~ eastern and western North America, western Europe, and Japan. Results generally confirm the existence of significant northward flux, 10-18 km, in winter/spring, ~~as shown by previous investigators.~~ However, areas of significant equatorward flux have been found at high mid-latitudes, 10-16 km,


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over North America in winter/spring and at all latitudes, 10-18 km, over Japan in spring. Fluxes are typically small in summer, as well as throughout the troposphere, and throughout most of the middle stratosphere. ~~Additional,~~ qualitative, statements are made concerning the relative importance of mean meridional and standing eddy fluxes.

Rocketsonde data, 30-60 km, 1961-1976, are the data base used for the three components of the eddy diffusion matrix and circulation statistics. ~~presented~~ in Part II. Horizontal diffusivities, Kyy, are obtained from the variance of the meridional wind and the meridional wind's integral time scale. The present results are generally smaller than past estimates, presumably because temporal variations longer than a month were ~~have been~~ filtered out in this work. Estimates of $K_{yz}$ are based on the tentative assumption that the diffusivity is proportional to the slope of the isentropic surfaces. Vertical diffusivities, $K_{zz}$, are based on a method proposed by Hines, and the present results agree well with past work. For the first time, means, variances, and covariances of wind and temperature have been prepared using the same data handling and analysis methods and the same data base for all components.

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## PART I

## THE OBSERVED OZONE FLUX BY TRANSIENT EDDIES, SURFACE TO 30 KM

### A. INTRODUCTION

Although constituting less than one-millionth part of the atmosphere by volume, ozone is of vital importance to the biosphere through its absorption of certain harmful ultraviolet wavelengths and its regulation of the thermal structure of the stratosphere. It has long been known that photochemical theory, by itself, fails to account for the observed ozone distribution, and atmospheric motions are largely responsible for the distribution in the lower and middle stratosphere. A basic disagreement, however, concerns the relative importance of mean motions and turbulent motions (the "eddies") in accomplishing this distribution. It has been maintained by some (e.g., Brewer, 1949; Dobson, 1973) that a mean meridional circulation transports ozone-rich air directly from the tropical middle stratosphere to the high latitude lower stratosphere. The other school of thought is that the eddies are primarily responsible for the poleward flux of ozone, at least in middle latitudes, and this view is much more dynamically reasonable. That eddies play an important role in the poleward ozone flux has been argued by Martin (1956), Godson (1960), and Newell (1961, 1964), among others.

If $X$ represents the instantaneous concentration of ozone and v represents the instantaneous northward wind, then the total northward flux of $X$ past any particular point is given by

$$\overline{vX} = \bar{v}\,\bar{X} + \overline{v'X'}. \qquad (1)$$

Here the overbar signifies a time average and a prime the deviation therefrom. The first term on the right of (1) is the flux due to the mean northward wind past a single point and is thus composed of a contribution by a) the zonally averaged, time averaged, northward wind (the "mean meridional circulation") and b) the deviation from the mean meridional circulation of $\bar{v}$ at the point (the "standing eddies"). With the present network of ozone and rawin stations, it is not possible to distinguish between contributions a) and b) at single stations. The second term on the right of (1) is the flux due to the "transient eddies", and this term we are able to evaluate at stations where both v and $X$ are observed.

It should be emphasized that, in addition to the horizontal mean and eddy fluxes, there are eddy and mean vertical fluxes which are certainly an important part of the global flux picture. Since vertical wind is not measured, it is not possible to directly compute vertical fluxes, even if one had much better station coverage.

Several investigators have carried out the transient eddy flux computation for ozonesondes at individual stations: Hering (1966) for Seattle, Fort Collins, and Bedford; Pittock (1968) for Aspendale, Australia; Dütsch and Favarger (1969) for Boulder; Hutchings and Farkas (1971) for Christchurch, New Zealand; and DeMuer (1976) for Uccle. Although these results varied from station to station, they generally showed a large horizontal transient eddy flux of ozone at about 12 - 16 km over mid-latitudes in winter and spring, with small, or even negative, fluxes in other seasons and at other heights. All these studies were for mid-latitude stations.

The present study uses similar methods as the previous studies, but encompasses more stations and regions. Specifically, these regions are Japan (3 stations), western North America (6 stations), eastern North America (12 stations), and western Europe (6 stations). Presented are seasonal height-latitude tables and cross sections for each region.

## B. DATA AND COMPUTATIONAL METHOD

### 1. Data

The data used in this study are described in Table 1 and in Figures 1-3. The North American ozone data were primarily from the Air Force Cambridge Research Laboratories' (AFCRL) 1963-1965 sounding network (and the extension until 1969 at a few stations). These data were obtained from World Data Center-A (Asheville). Most of the remaining data were obtained through the World Data Center for Ozone, Downsview, Ontario, Canada. Data for Boulder and Thalwil were extracted from Dütsch (1966) and Dütsch, et al. (1970).

Nastrom (1978) has shown that ozone and northward wind are nearly 90$^\circ$ out of phase in the extratropical lower stratosphere, with the v maximum lying to the east of the ozone maximum. Typical $X$,v correlations are quite small,

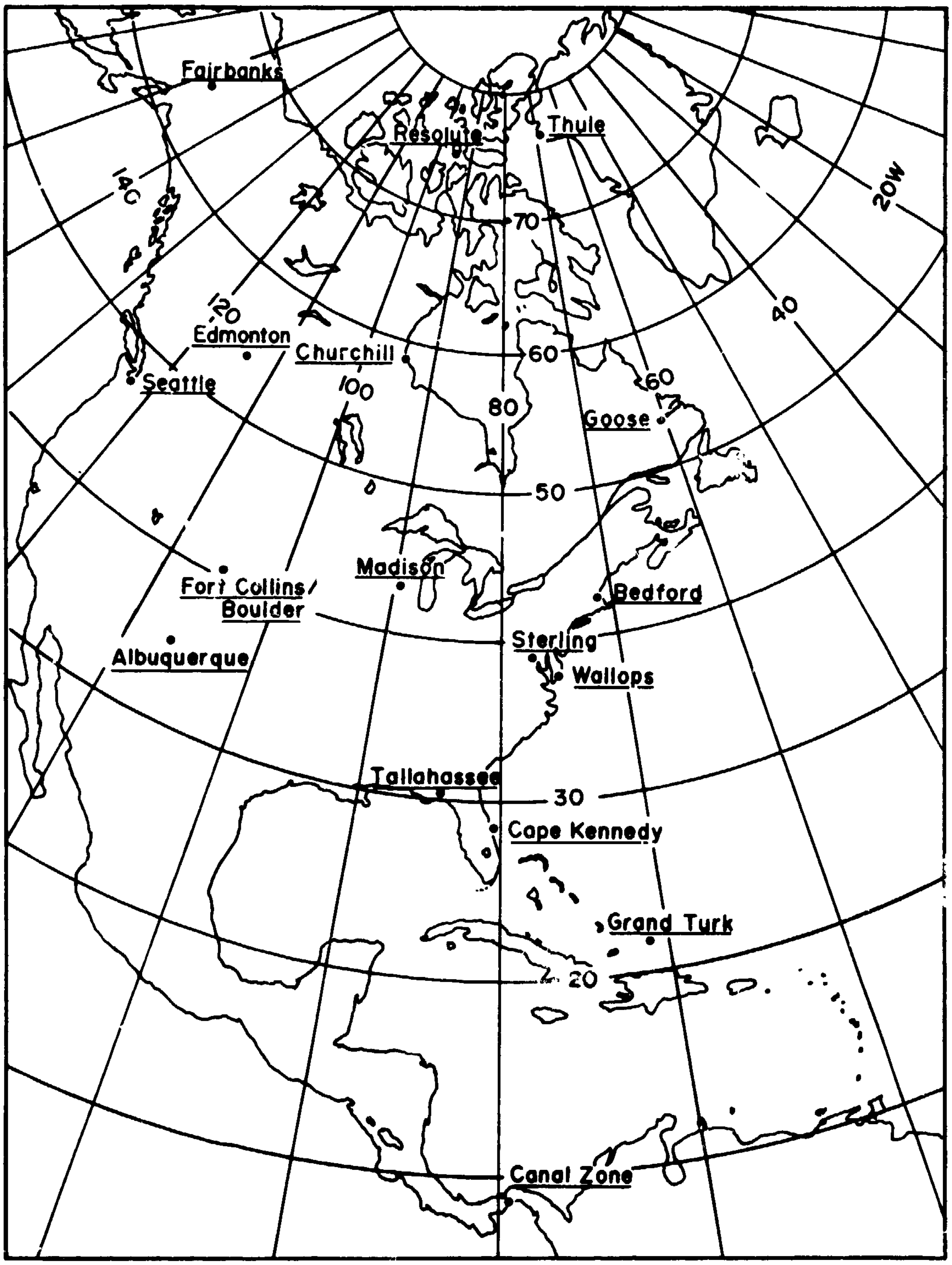


FIGURE 1. North American ozonesonde stations. 100°W divides "western" and "eastern" North America.

TABLE 1. Ozone and wind data.

| Ozone Station | | | | Wind Station[1] | | | | Flux Calculations | |
|---|---|---|---|---|---|---|---|---|---|
| Station | Lat. | Long. | Source[2] | Station | Lat. | Long. | Distance from ozone station | Period of record | No. of independent[3] pairs at 200 mb |
| **EASTERN NORTH AMERICAN STATIONS** | | | | | | | | | |
| Canal Zone | 9.0N | 79.6W | A | | Same | | | 1/63 - 5/69 | 81 |
| Grand Turk | 21.5 | 71.1 | A | | Same | | | 12/63 - 5/69 | 68 |
| Cape Kennedy | 28.4 | 80.5 | A | | Same | | | 2/66 - 5/69 | 85 |
| Tallahassee | 30.4 | 84.3 | A | Valparaiso | 30.5N | 86.5W | 211 km | 1/63 - 12/65<br>4/68 - 5/68 | 60 |
| Wallops Is. | 37.8 | 75.5 | A | | Same | | | 2/67 - 5/69 | 195 |
| Wallops Is. | | | T | | | | | 5/70 - 4/75<br>3/76 - 12/76 | |
| Sterling | 39.0 | 77.5 | T | | | | | 8/62 - 6/66 | 143 |
| Bedford | 42.5 | 71.3 | A | Portland | 43.7 | 70.3 | 156 | 9/63 - 5/69 | 321 |
| Bedford | | | T | | | | | 6/69 - 3/71 | |
| Madison[6] | 43.1 | 89.4 | A | Green Bay | 44.5 | 88.1 | 187 | 1/63 - 12/65 | 63 |
| Goose Bay | 53.3 | 60.4 | T | | | | | 1/63 - 12/63<br>6/69 - 12/76 | 504 |
| Goose Bay | | | A | | Same | | | 1/64 - 5/69 | |
| Churchill | 58.8 | 94.1 | A | | Same | | | 1/63 - 12/65 | 194 |
| Churchill | | | T | | | | | 10/73 - 12/76 | |
| Resolute | 74.7 | 95.0 | T | | | | | 1/66 - 12/76 | 476 |
| Thule | 76.5 | 68.8 | A | | Same | | | 1/63 - 1/66 | 68 |
| **JAPANESE STATIONS** | | | | | | | | | |
| Kagoshima | 31.6N | 130.6E | T | | Same | | | 12/68 - 12/75 | 178 |
| Tateno | 36.1 | 141.3 | T | | Same | | | 3/68 - 12/75 | 178 |
| Sapporo | 43.0 | 140.1 | T | | Same | | | 12/68 - 12/75 | 205 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **WESTERN NORTH AMERICAN STATIONS** | | | | | | | | | |
| Albuquerque | 35.0N | 106.6W | A | | Same | | | 1/63 - 12/65 | 136 |
| Boulder[4] | 40.0 | 105.2 | D1,D2 | Denver | 39.8N | 104.9W | 44 km | 8/63 - 7/66 | 342 |
| Fort Collins | 40.6 | 105.1 | A | Denver | 39.8 | 104.9 | 92 | 1/63 - 6/67 | 160 |
| Seattle | 47.4 | 122.3 | A | Salem[5] | 44.9 | 123.0 | 283 | 1/63 - 12/65 | 78 |
| Edmonton | 53.5 | 114.1 | T | | | | | 10/70 - 9/77 | 247 |
| Fairbanks | 64.8 | 147.9 | A | | Same | | | 9/63 - 9/64 | 83 |
| Fairbanks | | | T | | | | | 11/64 - 12/65 | |
| **WESTERN EUROPEAN STATIONS** | | | | | | | | | |
| Lisbon | 38.8N | 9.2W | T | | | | | 6/73 - 12/75 | 80 |
| Cagliari | 39.2 | 9.0E | T | | | | | 7/68 - 7/70<br>1/73 - 8/76 | 206 |
| Payerne[4,7] | 46.8 | 6.9 | T | | Same | | | 8/68 - 6/72 | 606 |
| Thalwil | 47.3 | 8.6 | D2 | Payerne | 46.8N | 6.9E | 132 | 9/66 - 7/68 | |
| Hohenpeissenberg | 47.8 | 11.0 | T | | | | | 3/65 - 12/76 | 571 |
| Uccle | 50.8 | 4.3 | T | | | | | 12/65 - 8/67 | 88 |
| Berlin[7] | 52.5 | 13.4 | T | | | | | 11/66 - 1/73 | 439 |
| Lindenberg[7] | 52.2 | 14.1 | T | | | | | 1/75 - 12/76 | |

NOTES

1 If all columns under this heading are blank, wind and ozone are from the same sounding. If the word "Same" appears, soundings are at the same station but at different hours.

2 Sources: T = World Data Center for Ozone, Downsview, Ontario; A - World Data Center-A, Asheville, NC; D1 = Dütsch (1966); D2 = Dütsch, et al. (1970).

3 Observations are judged independent if they are separated by at least 42 hours. See text.

4 These ozonesonde data were not accompanied by temperature, so concentrations have been calculated using temperature data at the wind station.

5 For the period 9/63 - 12/63 Olympia (47.0N, 122.9W) wind data was used.

6 The observations were actually moved to Green Bay in October 1964.

7 Thalwil and Payerne have been merged into single time series for this report, as have Berlin and Lindenberg.

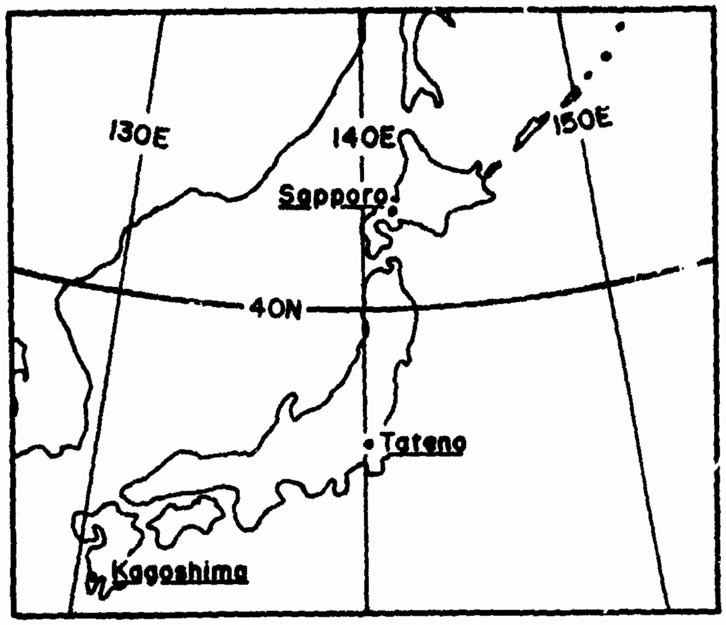


FIGURE 2. Japanese ozonesonde stations.

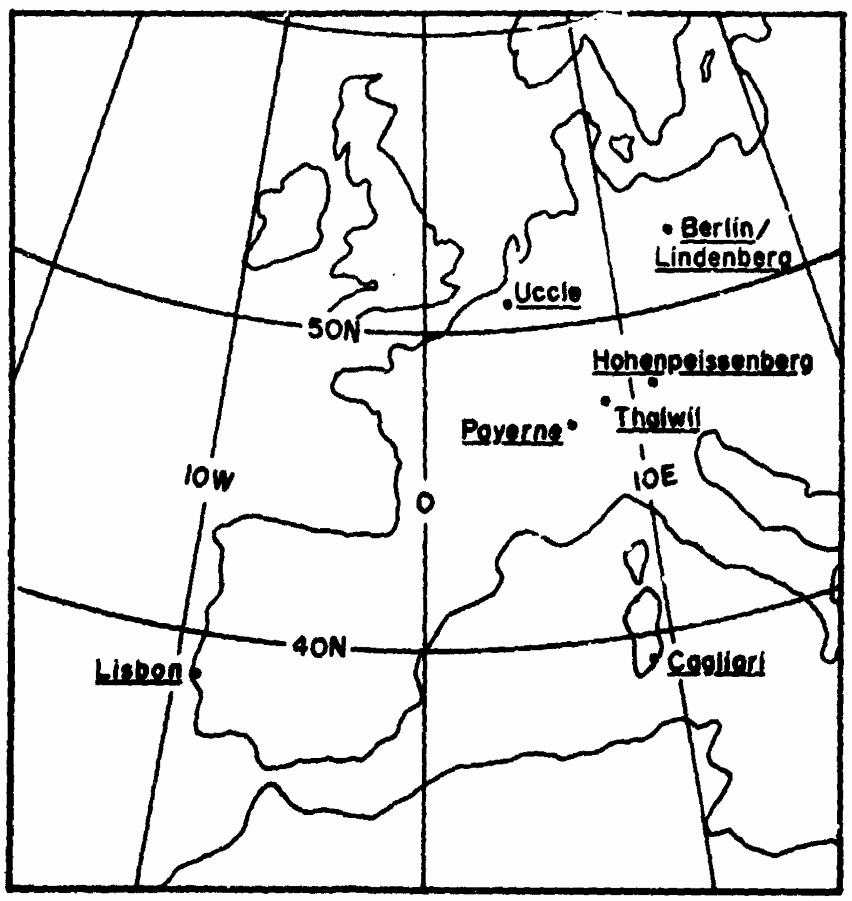


FIGURE 3. Western European ozonesonde stations.

and sensitive to space and time lags of the individual observations. It is therefore unfortunate that wind data accompanying the AFCRL soundings were discarded (Hering, personal communication, 1977) and that, at a few other stations, wind data were not routinely reported. When concomitant wind was not available, data within ±8 hours from a nearby rawin station were used. Such rawinsonde data were obtained from World Data Center-A. For the few ozone stations which did not report temperature (needed for determination of concentration), temperature was also taken from this rawinsonde report.

The choosing of a rawin station to pair with an ozone station was usually based simply on separation distance, but consideration was also given to the fact that v is about twice as highly autocorrelated in the north-south direction as in the east-west direction in the upper troposphere (Buell, 1973), and probably in the lower stratosphere as well. Therefore, Seattle is paired with Salem (283 km south) rather than with Tatoosh Is. (210 km west).

All wind data were objectively checked using a vertical wind shear criterion proposed by Essenwanger (1967). Temperature was also required to pass certain vertical consistency checks (details available on request). The computation of flux was carried out for the levels 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10, and 7 mb. Values at 2.5 km height increments were subsequently read off the analyses, according to seasonal mean height-pressure relationships in the standard atmospheres of various latitudes (U.S. Standard Atmosphere Supplements, 1966).

There have been occasional periods at a few ozone stations when ascents were made only a few hours apart. This often led to the pairing of two or even three ozonesondes with a single rawinsonde. When this happened, the ozone data were averaged and henceforth treated as one observation.

## 2. Flux Computation

In computing seasonal mean fluxes, care was taken not to give undue weight to observation series whose temporal density indicated the individual observations were not independent in the statistical sense. Wilcox (1978) determined that total ozone observations (at middle latitudes) may be considered independent if they are four days apart. Comparing Nastrom (1977, Figure 2), it seems that local ozone is even more highly variable. Here we have arbitrarily set 42 hours as the threshold beyond which independence is assumed, and averages are taken over any group of observations which are less than 42 hours apart. This average is used, but weighted by the square root of the number of such observations in the group, in the computation of mean flux over a single season. $\overline{F}_j$, the flux for individual season j (j=1,...,J, where J is the number of years used) is

$$\overline{F}_j = \left[\frac{1}{\sum_{i=1}^{I}\sqrt{n_i}} \sum_{i=1}^{I} v_i X_i \sqrt{n_i}\right]_j - \left[\frac{1}{\sum_{i=1}^{I}\sqrt{n_i}} \sum_{i=1}^{I} v_i \sqrt{n_i}\right]_j \cdot \left[\frac{1}{\sum_{i=1}^{I}\sqrt{n_i}} \sum_{i=1}^{I} X_i \sqrt{n_i}\right]_j \qquad (2)$$

in which $n_i$ is the number of observations in the ith observation group, and I is the number of groups in the season. Usually, there was only one observation per group, in which case, $n_i = \sqrt{n_i} = 1$. But, as described above, when observations within a group were not thought to be independent, $n_i$ is equal to the number of observations whose <u>average</u> was used for $X_i$ and $v_i$.

Note that (2) is term-for-term analagous, except for the weighting, with the more concise notation

$$\overline{F}_j = \overline{vX} - \overline{v}\,\overline{X}. \qquad (2a)$$

In forming the long-term seasonal flux, $\overline{F}$, the $\overline{F}_j$s were weighted by the square root of $N_j$, where $N_j = \sum_{i=1}^{I}\sqrt{n_{ij}}$, i.e.,

$$\overline{F} = \frac{1}{\sum_{j=1}^{J}\sqrt{N_j}} \sum_{j=1}^{J} \overline{F}_j \sqrt{N_j} \qquad (3)$$

It will be noted that this computational method does not take into account the positive correlation of seasonal changes in X and v in the mid-latitude lower stratosphere. This correlation, when positive, makes an algebraically positive contribution to the flux (see Nastrom, 1977). However, the effect is not thought to be serious over the three-month averaging periods, and efforts to account for the variability would, in any case, be inaccurate due to dearth of data.

3. Standard Errors

Standard errors, $\sigma_{\bar{F}}$, of the long-term seasonal mean fluxes, were estimated by

$$\sigma_{\bar{F}} = \frac{\sigma_X \sigma_v}{\left[\left(\sum_{j=1}^{J} N_j\right) - 4\right]^{\frac{1}{2}}} \tag{4}$$

where $\sigma_X$ and $\sigma_v$ are the standard deviations of ozone and northward wind, respectively (Panofsky and Brier, 1958, p.93). Standard errors helped to guide the analysis in areas where individual fluxes were spatially inconsistent.

## C. ANALYSIS AND RESULTS

Fluxes were statistically insignificant, typically, over most of the altitude range considered. Usually, it is only just above the tropopause that the magnitudes of individual fluxes surpass twice the standard error (i.e., 95% confidence in the sign). These regions, usually in mid-latitudes, from 10 to 18 km, show significant winter and spring fluxes which are generally poleward, except equatorward over Japan and at high mid-latitudes over North America. Above and below these regions, and at all altitudes of low latitudes, the fluxes are generally small, but usually, through consideration of fluxes at several levels and/or stations, a good guess at the proper sign can be made.

1. Eastern North America (Figure 4 and Table 2)

During winter and spring, there is a region of very significant northward (positive) flux near 40N from about 10 to 16 km. This is in qualitative and

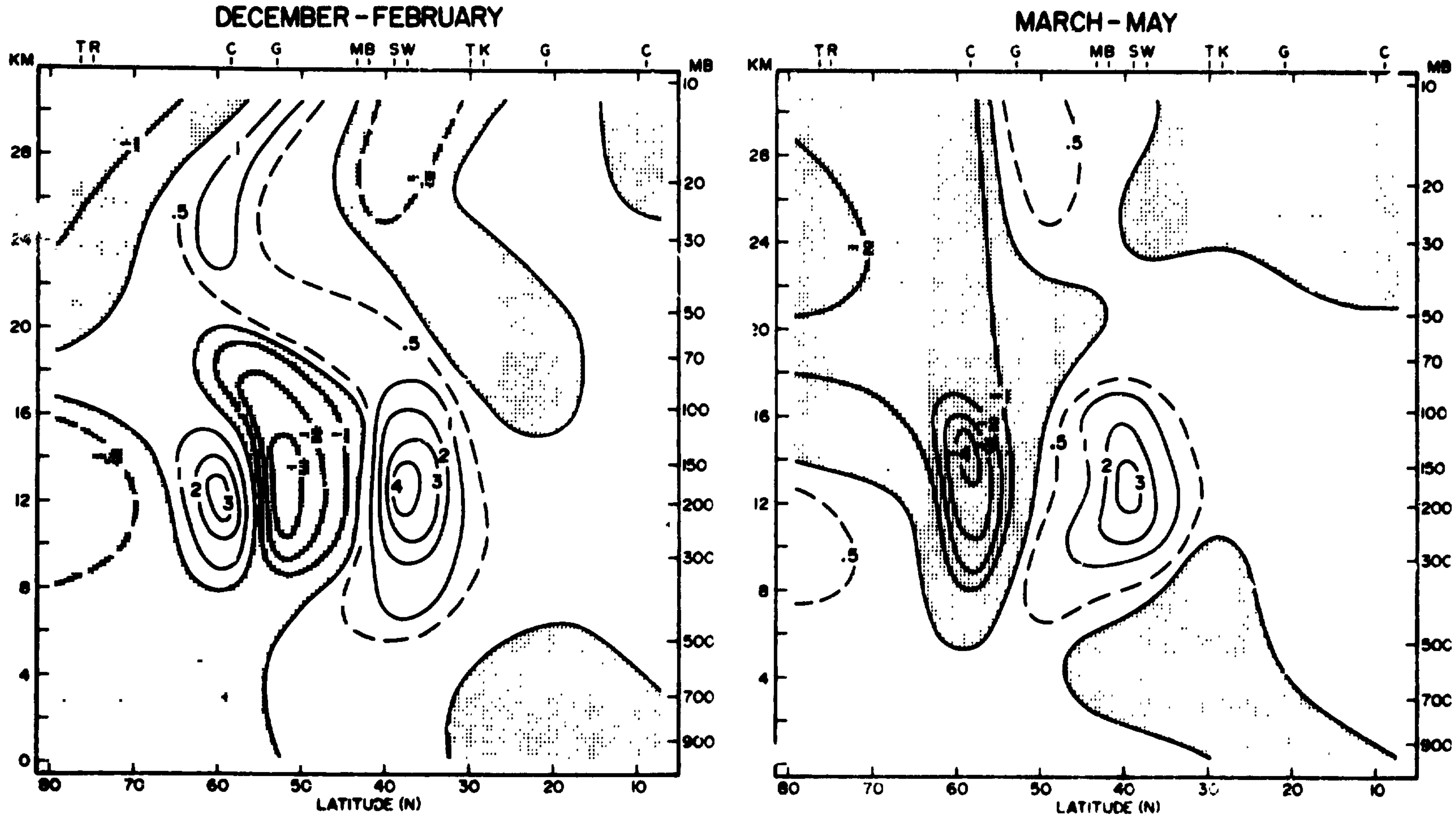


**FIGURE 4.** Northward ozone flux by the transient eddies over eastern North America. Units are $10^{18}$ molecules $m^{-2}$ $sec^{-1}$. Letters at the top refer to stations (Table 1). Southward regions shaded.

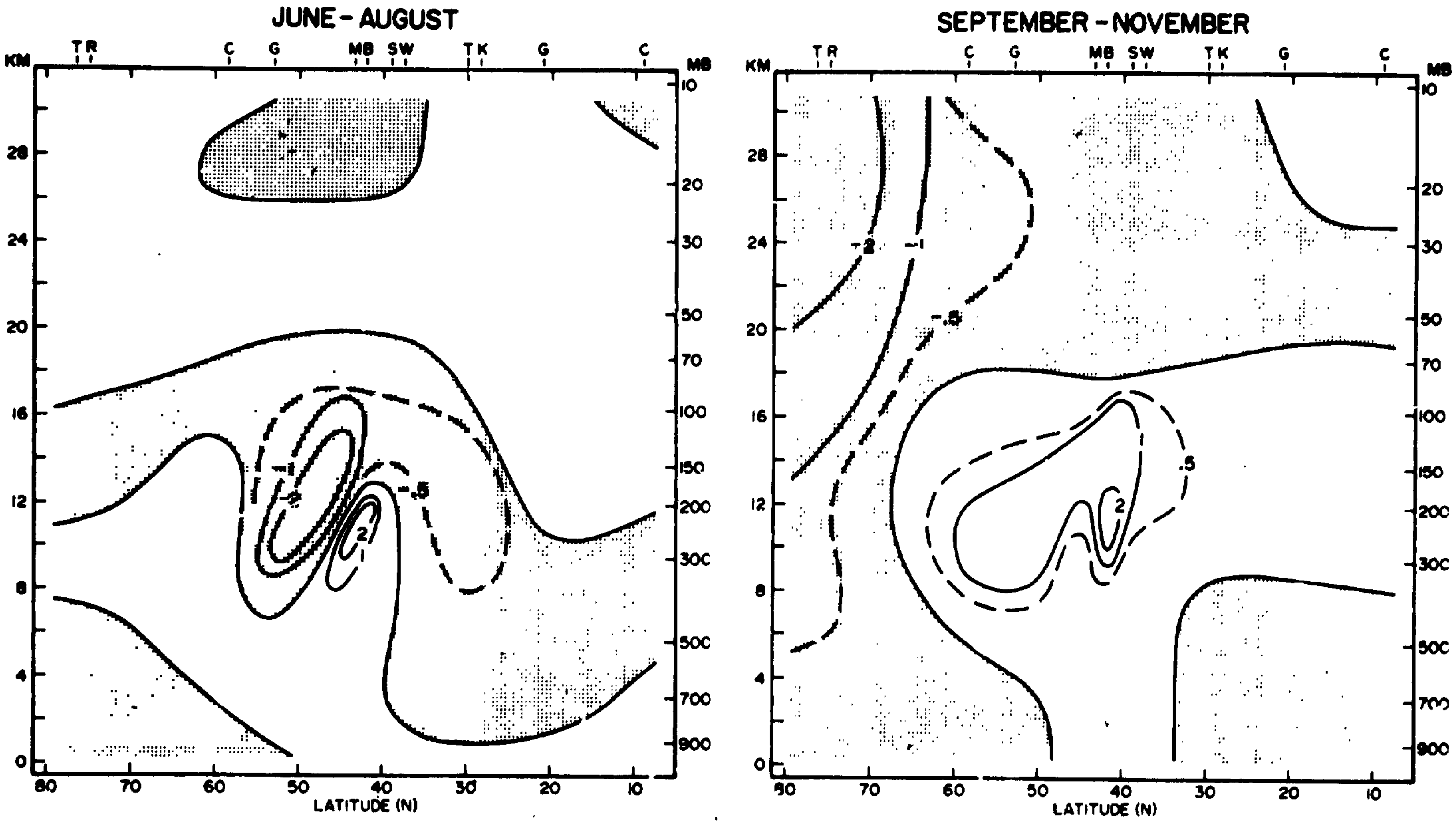


FIGURE 4. (Continued).

reasonable quantitative agreement with the countergradient fluxes found in previous studies (Hering, 1966; Dütsch and Favarger, 1969). However, the present analysis shows negative (downgradient) fluxes at Goose Bay in winter and at Churchill and Goose Bay in spring above about 8 km. Such negative fluxes have been found in individual seasons, at other locations, by Newell (1964), Pittock (1968), and Nastrom (1977).

During summer, computed fluxes tend to have modest negative values in the mid-latitude low stratosphere, returning to positive values by autumn. In the tropics, as well as throughout the troposphere and the subpolar middle stratosphere, the computed ozone flux is small in magnitude and uncertain in sign.

At high latitudes over eastern North America (shown mainly by Resolute), the flux is fairly large southward in all seasons but summer. However, a longitudinally uniform southward flux of such a magnitude would imply an unreasonably large compensating downward flux through the 30 km level over polar regions. Such a downward flux would have to be at least an order of magnitude larger than what is predicted by K-theory using diffusion coefficients from Part II of this work, or from other investigations (see CIAP, 1975). We conclude that there is either a large longitudinal variability in the transient eddy flux at high latitudes, or else standing eddy fluxes compensate. In this connection, it should also be mentioned that observations were not sorted according to whether there was a "sudden stratospheric warming" occurring or not. Such warming periods are thought to be a primary mechanism through which ozone is advected from middle to polar latitudes (Godson, 1960; Clark, 1970). Since the flux would therefore be of different character during these periods, a statistically unrepresentative sampling of the arctic winter stratosphere would have a profound affect on computed fluxes. Extreme caution should accompany any use of these high latitude results.

2. <u>Western North America</u> (Figure 5 and Table 3)

Western North America again shows significant northward flux near 40N, 8-16 km, except in summer. There is a tendency, as over eastern North America, for high mid-latitude stations to evidence equatorward flux. This is particularly true at Seattle, which has relatively few observations and whose "concomitant" winds came from a fairly distant station, but the more reliable Edmonton data suggests negative fluxes also.

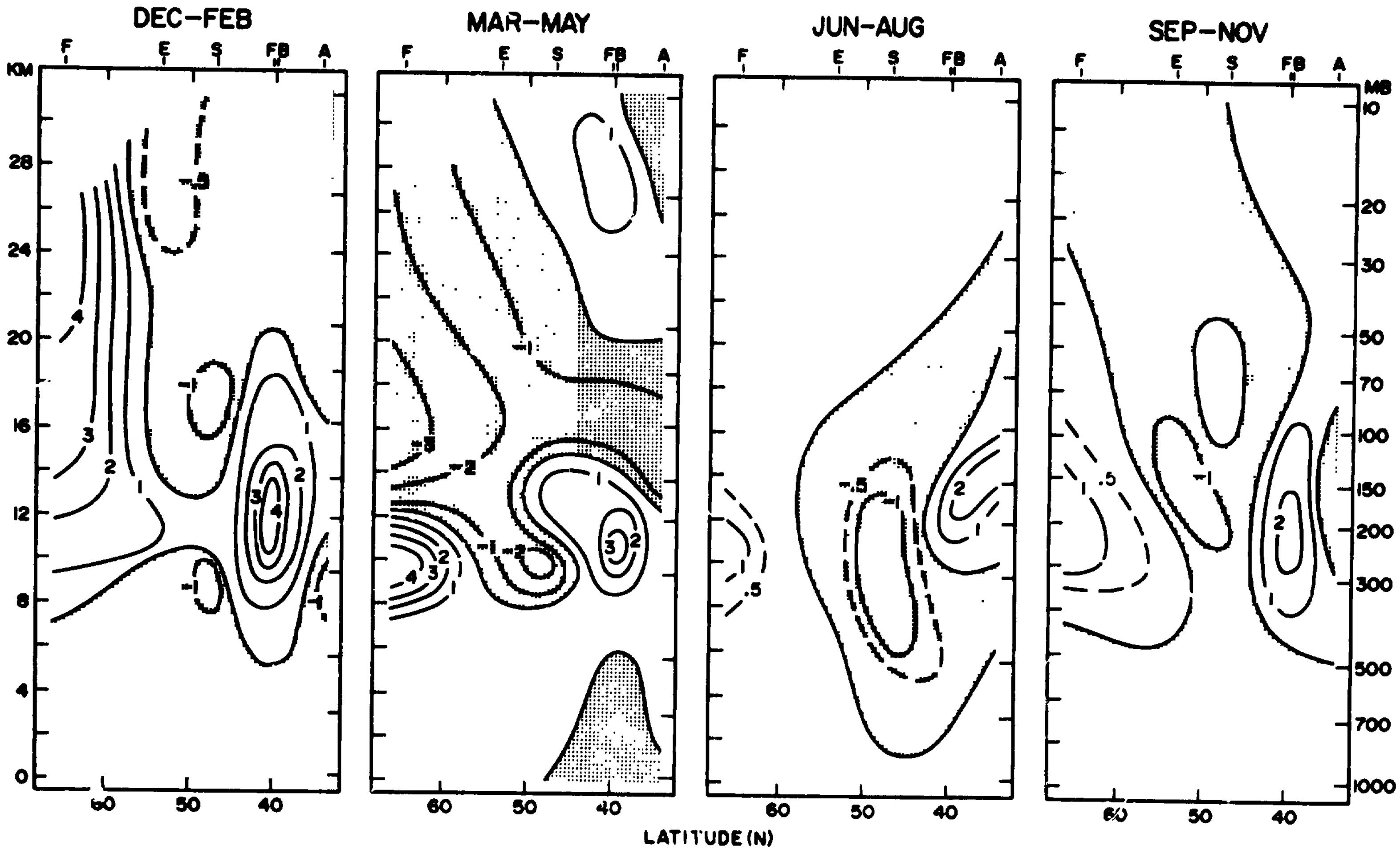


FIGURE 5. Northward ozone flux by the transient eddies over western North America. Units are $10^{18}$ molecules $m^{-2}sec^{-1}$. Letters at top refer to stations (Table 1). Southward regions shaded.

North of 60N, an area represented solely by the scanty data of Fairbanks, large positive fluxes above 16 km in the winter are replaced by negative fluxes in the spring, while very large positive fluxes are seen in spring just above the tropopause, 8-11 km. Fairbanks values should be taken as suggestive only. South of 60N and above 18 km fluxes are small throughout the year, as they also are in the troposphere.

D. Western Europe (Figure 6 and Table 4)

Sizeable northward fluxes exist over western Europe in winter between 40 and 50N, 10-14 km. In spring the main center of northward flux seems to have moved farther northward. Interestingly, although the farthest north station, Berlin/Lindenberg, approaches the latitudes of Goose Bay and Edmonton, it does not show the negative winter and spring fluxes that exist at the latter stations.

Flux remains positive at 10-14 km for most stations in summer but is only less than half as large as during winter. During autumn, small positive fluxes exist at almost all levels above the tropopause.

4. Japan (Figure 7 and Table 5)

In winter, the Japanese data paint a picture of negative fluxes 16-22 km over Kagoshima (32N) and below 14 km over Sapporo (43N), and generally positive fluxes elsewhere. At their largest values ($\sim 1.5 \times 10^{18}$ molecules $m^{-2} sec^{-1}$, hereafter called "units") at around 14-16 km, these positive fluxes are significantly smaller than the positive wintertime fluxes seen in the other regions.

In spring, significant negative fluxes occur at all three stations from about 10-16 km, especially at Sapporo where the 150 mb flux is $5.8 \pm 2.5$ units (95% confidence limits). At Sapporo, the flux becomes strongly northward in summer and autumn just above the tropopause, while at the other stations the pattern is nondescript, but with a tendency toward small negative values.

## D. DISCUSSION

### 1. Comparison with Previous Observational Results

It is worthwhile to compare the present results with previous investigations of the transient eddy ozone flux made at individual stations, or at

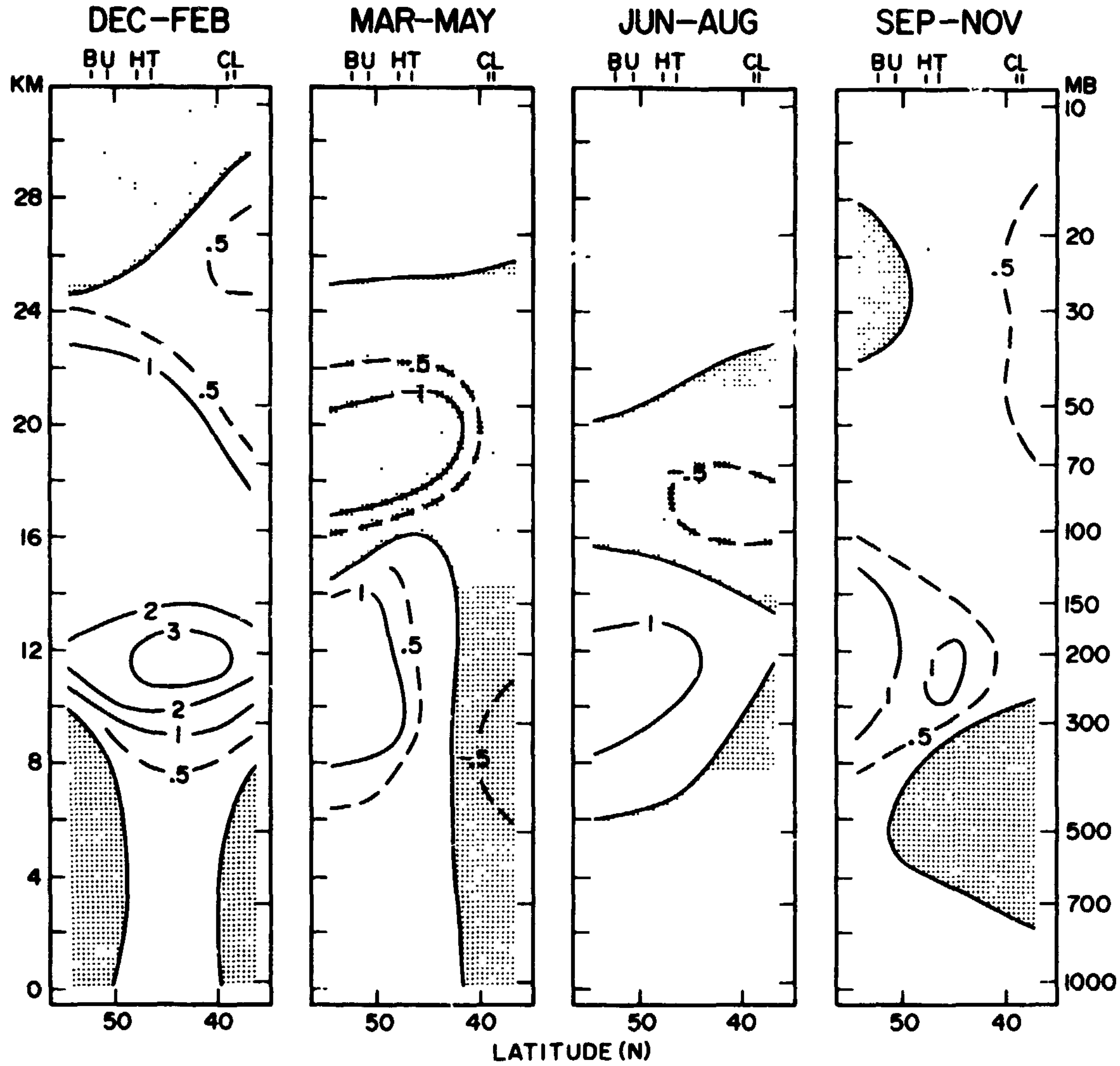


FIGURE 6. Northward ozone flux by the transient eddies over western Europe. Units are $10^{18}$ molecules $m^{-2}sec^{-1}$. Letters at the top refer to stations (Table 1). Southward regions shaded.

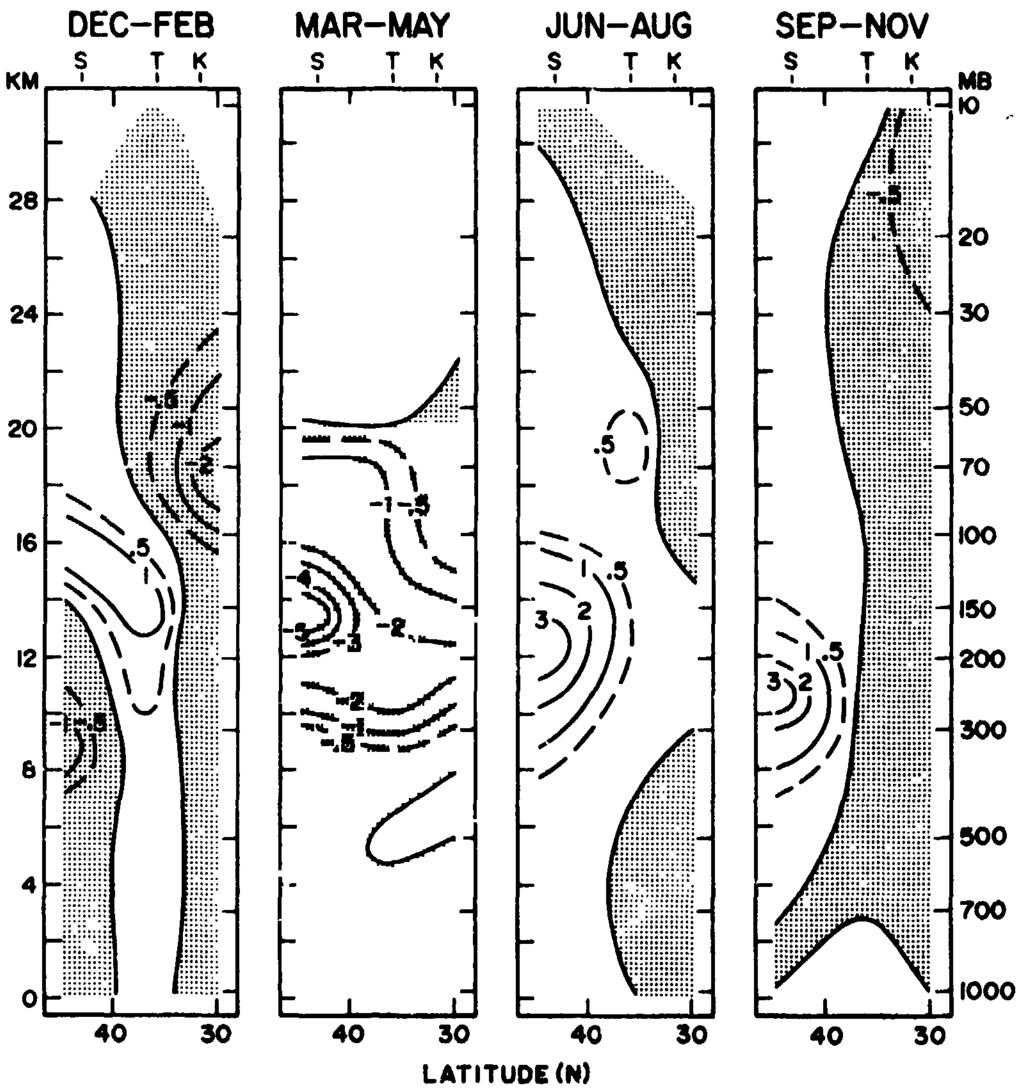


FIGURE 7. Northward ozone flux by the transient eddies over Japan. Units are $10^{18}$ molecules $m^{-2} sec^{-1}$. Letters at the top refer to stations. Southward regions shaded.

groups of a few stations (as in the case of Hering, 1966). However, although the present study includes the stations used in several of these previous investigations, differences in period of record, availability of wind data, and computational technique make differences in results inevitable.

All previous investigations of the ozone flux which used ozonesondes have been for mid-latitude stations. They have all shown positive winter and spring fluxes from about 10-18 km, with maxima at about 12 km. Dütsch and Favarger (1969) have computed this maximum to be 3.8 units in winter and 2.7 units in spring for two years at Boulder, while Hering puts it at 5.0 units for an average of two years' December-May fluxes at Seattle, Fort Collins and Bedford. (It is not clear whether or not Hering removed the flux due to the correlations between the annual waves of v and $X$. While we did not remove this correlation either (see Section B), Hering's longer averaging period (six months) would have more serious consequences (Nastrom, 1977).)

At Aspendale, Pittock (1968) found 200 mb poleward fluxes of 2.6 units in some winters or springs, but equatorward fluxes (of up to 4.0 units) in others. Hutchings and Farkas (1971), from a very small data sample at Christchurch, determined an annual average flux at the 12 km level of about 3.1 units. Not included in the present report are several recent years of soundings at Uccle, from which DeMuer (1976) has computed fluxes. His annual mean value at 200 mb is 1.5 units which compares well with our annual mean at nearby (in latitude) Berlin (1.4 units).

Nastrom (1977) has computed fluxes between 11 and 12 km, 10-60N, from one year of simultaneous wind and ozone measurements aboard commercial aircraft. Again, his fluxes are in reasonable agreement with the present values, especially considering the very different sampling characteristics.

Of course, comparisons of results could be made for every level and season, but the main point can now be stated very simply: The present results are consistent, in the main, with previous results, despite differences in data and computational method. This fact should lend confidence to the new results presented here, most notably the negative fluxes over Japan and North America, and, in general, the large latitudinal variability of the fluxes. It is also clear from the regional differences in the present results that there is a large longitudinal and/or interannual variability in the transient eddy flux of ozone. This comes as no surprise, as Nastrom (1977) has also provided such a picture at 11-12 km, 40-50N. In particular, for one March in the longitude sector 120E-180 (i.e., mostly north and east of Japan), Nastrom found a negative flux of 6 units, while most other longitude sectors showed positive fluxes of varying magnitudes. The negative spring Japan flux agrees well with the values deduced from ozonesondes. It is also evident from the aircraft data that equatorward fluxes occur in other longitude sectors, sometimes at latitudes as far south as 40N, but that there is considerable interannual variability in this latitude, as can also be inferred from the results of Newell (1964) and Pittock (1968). Interestingly, spring is the only season in which Newell (1964), in his correlations of v with total ozone, did not infer a negative transient eddy flux in the lower stratosphere over Japan. It is for these reasons of significant longitudinal and interannual variability that we have chosen not to try to combine our regional fluxes.

## 2. Qualitative Remarks on the Ozone Flux Budget

Similarities between patterns of the zonal mean observed isentropes and ozone concentrations imply that the countergradient ozone flux is effected by the same process that effects the countergradient heat flux. The spatial relationship of temperature and height fields in the mid-latitude lower stratosphere indicates the subsidence of air in the troughs and the ascent of air in the ridges. Wallace (1978) has explained that air must move through a lower stratospheric trough at a subgeostrophic speed and that, conversely, air moving through a ridge must do so at a supergeostrophic speed; that is, there is a poleward acceleration in the troughs and an equatorward acceleration in the ridges. Combined with the fact that potential temperature increases with height, this process leads to the observed downward, poleward (countergradient) heat flux. Ozone, since its concentration also increases with height, is transported downward and poleward by the same process.

This explanation predicts only poleward flux throughout mid-latitudes, as is observed in the case of both standing and transient eddy heat flux (Oort and Rasmusson, 1971, pp.286-289). However, the present results for ozone indicate an equatorward transient eddy flux in winter and especially spring at high mid-latitudes. Newell (1964) has suggested that the negative fluxes he found over Japan may be associated with stratosphere-troposphere exchange processes. This association is appealing, since the large convergence of ozone between the positive and negative fluxes would have to be in large part balanced by downward removal into the troposphere. However, association does not necessarily imply cause, and we cannot at present offer a dynamical explanation of the high mid-latitude equatorward fluxes. We can, however, note a strong association with the mean potential temperature field. Climatology (Labitzke, 1972; U.S. Weather Bureau, 1966) shows that areas near Japan and eastern North America have 200 mb potential temperature maxima which are both relatively stronger and located more equatorward than those over western North America and, especially, Europe. These features correlate well with our analyzed patterns of the locations and strengths of the equatorward ozone flux.

It is desirable to make some qualitative assessment of the relative importance of standing and transient eddy ozone fluxes, and we do this via comparison of the present transient eddy results with a three-dimensional model's predictions of total eddy fluxes (steady plus transient). Prinn, et al. (1978), have shown total eddy fluxes, integrated throughout the depth of the model atmosphere, for an annual cycle of their three-dimensional dynamical-chemical model. To compare our results, we have also integrated from the surface to 30 km for the eastern North America sector only (Figure 8). The model's total eddy flux at its wintertime maximum (50N) is one and a half times as large as our transient eddy flux at our maximum location of 37N. The model's winter eddy flux decreases rapidly toward pole and equator, but does not become negative, as ours does from 45-55N and again poleward of 65N. However, even if its transient and standing eddy fluxes were shown separately, it is likely that the model would fail to portray the southward transient eddy flux in winter north of 50N. As indicated previously, this feature can be associated with the existence of a potential temperature maximum at mid-latitudes, which this model fails to predict (Cunnold, et al., 1975; Prinn, et al., 1978).

There are clearly large differences between this model's (and other models') results and the present observational results which cannot be dismissed simply by noting that the models fail to reproduce the mid-latitude temperature

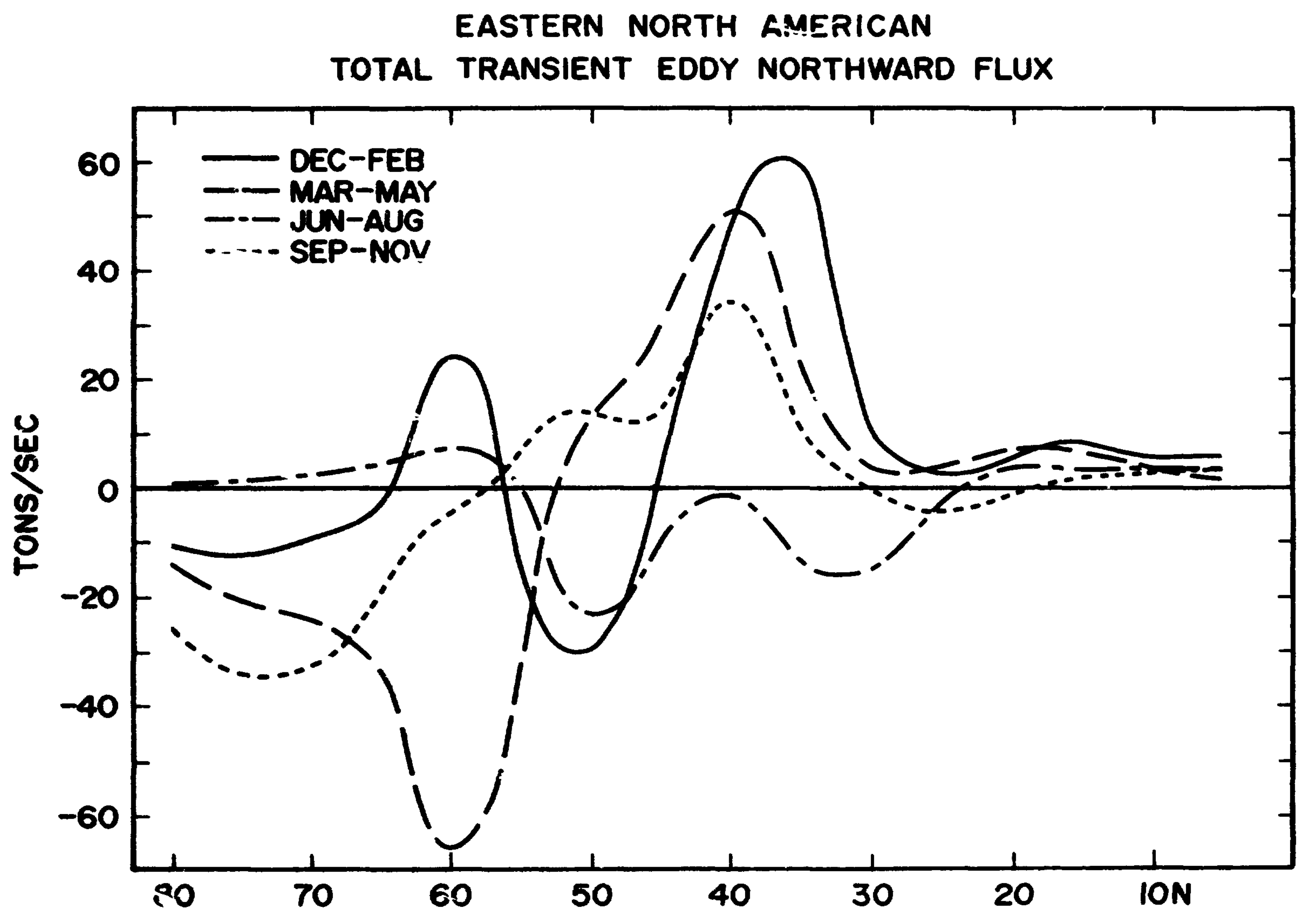


FIGURE 8. Northward transient eddy ozone flux, integrated from the surface to 30 km and around the latitude circle, using eastern North American fluxes only.

maximum. A major difference must be in the model's inclusion of standing eddies, which must make a large contribution to the total eddy ozone flux poleward of about 45N in all seasons except summer, when our results agree with the model's results fairly well. Since transient eddies are damped in the stratosphere, only the ultra-long, quasi-stationary waves are evident in the middle stratosphere, and those only in non-summer months. It is therefore reasonable to surmise that the standing eddy ozone flux is much larger than the transient eddy ozone flux above 18 km or so, and that it is basically the standing eddy flux which accounts for the rapid buildup of ozone near the level of the maximum concentration (about 20 km) at high latitudes in winter and early spring (see, e.g., Wilcox, et al., 1977). This suggestion has also been made by Dütsch and Favarger (1969). It might also be noted that the standing eddy heat flux (Oort and Rasmusson, 1971, pp.288-289) is comparable to the transient eddy heat flux (pp.286-287) in the mid-latitude lower stratosphere. We are led to infer that the standing eddy and transient eddy ozone fluxes are probably of comparable magnitude even in the lower stratosphere (i.e., tropopause to about 18 km).

The tropical mean meridional circulation (Hadley Cell) appears capable of transporting large amounts of ozone from its primary source region in the tropical middle stratosphere downward and poleward to the sub-tropics, and it is probably the major mechanism in so doing (Hunt and Manabe, 1968; Cunnold, et al., 1975). The mean meridional flux in mid-latitudes is almost certainly equatorward, but its magnitude is relatively uncertain. Model results range from portraying it as a minor effect (Cunnold, et al., 1975; Prinn, et al., 1978) to almost balancing the eddy flux (Hunt and Manabe, 1968; Mahlman and Moxim, 1978).

In conclusion, both the direct computations reported here and the results of other investigations imply that the transient eddy flux of ozone appears to be of at least equal importance to the standing eddy and mean meridional fluxes in the mid- and high-latitude lower stratosphere. Above about 18 km, the standing eddy flux is probably more important, and, in the tropics, the mean meridional flux is the primary agent of transport. Direct quantitative estimates of these horizontal fluxes, as well as indirect estimates of vertical fluxes, must necessarily await more spatially extensive observations.

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TABLE 2. Transient eddy ozone flux over eastern North America. Positive denotes northward. Units: $10^{18}$ molecules $m^{-2} sec^{-1}$.

SEASON: December - February

| km | 80N | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30.0 | -1.6 | -1.4 | -1.2 | -1.0 | -.4 | .5 | .8 | .2 | -.7 | -.7 | -.4 | .1 | .3 | .0 | -.6 | -.7 |
| 27.5 | -1.4 | -1.2 | -.6 | .0 | 1.0 | .8 | .3 | -.2 | -.6 | -.5 | .0 | .2 | .2 | .0 | -.3 | -.5 |
| 25.0 | -1.2 | -.6 | -.1 | .5 | 1.2 | .5 | .2 | .0 | -.5 | -.4 | .0 | .2 | .2 | .1 | .0 | .0 |
| 22.5 | -.5 | -.3 | .0 | .4 | 1.0 | .7 | .4 | .2 | -.2 | -.4 | -.3 | -.1 | .1 | .2 | .4 | .4 |
| 20.0 | -.1 | .0 | .1 | .1 | .0 | .5 | .7 | .6 | .6 | .0 | -.3 | -.3 | -.1 | .1 | .3 | .4 |
| 17.5 | .0 | .0 | .1 | .1 | -1.0 | -2.0 | -1.0 | .5 | .8 | .8 | .0 | -.2 | -.2 | .0 | .2 | .3 |
| 15.0 | -.6 | -.5 | .0 | .1 | .1 | -2.0 | -2.5 | -1.0 | 2.0 | 2.4 | .5 | .0 | .0 | .1 | .2 | .2 |
| 12.5 | -.7 | -.6 | -.5 | -.5 | 3.0 | -1.0 | -3.0 | -1.0 | 3.0 | 3.4 | .8 | .2 | .1 | .2 | .2 | .3 |
| 10.0 | -.7 | -.6 | -.5 | .0 | 1.8 | -1.0 | -2.0 | .5 | 2.2 | 2.4 | .8 | .3 | .2 | .3 | .3 | .3 |
| 7.5 | -.3 | -.3 | -.3 | -.2 | -.1 | -.2 | .0 | .6 | 1.2 | 1.2 | .4 | .2 | .1 | .1 | .1 | .1 |
| 5.0 | -.1 | -.1 | -.2 | -.2 | -.2 | .0 | .2 | .2 | .2 | .4 | .1 | .0 | .0 | .0 | .0 | .0 |
| 2.5 | .0 | .0 | -.1 | -.2 | -.2 | .0 | .2 | .3 | .2 | .2 | -.2 | -.2 | -.1 | .0 | .0 | .0 |

SEASON: March - May

| km | 80N | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30.0 | -1.6 | -1.6 | -1.4 | -1.2 | -1.2 | .3 | .7 | .4 | .1 | .0 | -.1 | -.1 | -.1 | -.1 | -.2 | -.3 |
| 27.5 | -2.2 | -1.8 | -1.6 | -1.4 | -1.2 | .0 | .6 | .5 | .1 | -.1 | -.1 | -.1 | -.1 | -.1 | -.1 | -.2 |
| 25.0 | -2.8 | -2.6 | -1.8 | -1.6 | -1.2 | .2 | .5 | .4 | .0 | -.1 | -.1 | -.1 | -.1 | -.1 | -.1 | -.1 |
| 22.0 | -2.8 | -2.6 | -2.0 | -1.6 | -1.2 | -.6 | .0 | .1 | .1 | .1 | .1 | .1 | .0 | .0 | -.1 | -.1 |
| 20.0 | -1.8 | -1.8 | -1.6 | -1.4 | -1.2 | -.8 | -.3 | -.1 | .1 | .4 | .4 | .3 | .2 | .1 | .0 | .0 |
| 17.5 | -.8 | -1.0 | -1.2 | -1.6 | -1.8 | -1.0 | -.2 | .3 | .5 | .5 | .4 | .4 | .3 | .2 | .1 | .1 |
| 15.0 | -.3 | -.5 | -.6 | -1.0 | -3.5 | -1.6 | .0 | 1.0 | 2.4 | 1.0 | .4 | .2 | .2 | .2 | .2 | .2 |
| 12.5 | .5 | .3 | .2 | -.5 | -3.0 | -2.4 | .1 | .8 | 3.4 | 1.4 | .4 | .2 | .2 | .2 | .2 | .2 |
| 10.0 | .7 | .6 | .4 | .0 | -2.0 | -1.2 | .5 | 1.4 | 2.0 | .8 | .0 | .2 | .2 | .2 | .2 | .2 |
| 7.5 | .5 | .5 | .4 | .1 | -.6 | -.2 | .6 | .6 | .3 | -.1 | -.4 | -.1 | .2 | .2 | .1 | .1 |
| 5.0 | .3 | .3 | .3 | .2 | .0 | .2 | .2 | -.1 | -.4 | -.5 | -.3 | -.2 | .1 | .1 | .1 | .1 |
| 2.5 | .2 | .2 | .2 | .2 | .2 | .1 | .1 | .1 | -.1 | -.2 | -.3 | -.2 | -.1 | .0 | .0 | .0 |

TABLE 2. (Continued).

**SEASON: June - August**

| km | 80N | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30.0 | .1 | .1 | .1 | .1 | .1 | .0 | -.1 | -.1 | -.1 | .0 | .2 | .1 | .1 | .0 | .0 | -.1 |
| 27.5 | .1 | .1 | .1 | .0 | .0 | -.1 | -.1 | -.1 | -.1 | .0 | .1 | .1 | .1 | .0 | .0 | .0 |
| 25.0 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 |
| 22.5 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .1 | .1 | .1 | .1 | .1 | .1 |
| 20.0 | .2 | .2 | .2 | .2 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .2 | .2 | .2 | .2 | .2 |
| 17.5 | .2 | .1 | .0 | .0 | -.1 | -.2 | -.4 | -.4 | -.4 | -.3 | .0 | .1 | .2 | .2 | .2 | .2 |
| 15.0 | -.2 | -.2 | -.2 | -.1 | .0 | -.4 | -1.0 | -2.0 | -.8 | -.8 | -.5 | .1 | .1 | .1 | .1 | .1 |
| 12.5 | -.1 | -.1 | .0 | .2 | .6 | -.5 | -2.0 | -2.0 | .0 | -.5 | -.7 | -.2 | .1 | .1 | .1 | .0 |
| 10.0 | .2 | .3 | .4 | .5 | .5 | .8 | -2.0 | 1.4 | .5 | -.4 | -.8 | -.4 | -.1 | -.1 | -.1 | -.1 |
| 7.5 | .0 | .1 | .2 | .2 | .2 | -.4 | .0 | .6 | .3 | -.2 | -.4 | -.2 | -.1 | -.1 | -.1 | -.1 |
| 5.0 | -.2 | -.2 | .1 | .1 | .2 | [illegible] | .3 | .3 | .1 | -.1 | -.1 | -.1 | -.1 | -.1 | -.1 | .0 |
| 2.5 | -.1 | -.1 | -.1 | -.1 | .0 | .2 | .3 | .3 | .0 | -.1 | -.1 | -.1 | -.1 | .0 | .0 | .0 |

**SEASON: September - November**

| km | 80N | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30.0 | -2.6 | -2.4 | -2.0 | -1.4 | -.5 | -.3 | -.2 | -.2 | -.2 | -.2 | -.2 | -.1 | .1 | .3 | .4 | .4 |
| 27.5 | -2.6 | -2.4 | -2.2 | -1.2 | -.8 | -.6 | -.3 | -.2 | -.1 | -.1 | -.1 | -.1 | .0 | .2 | .2 | .3 |
| 25.0 | -2.6 | -2.4 | -2.0 | -1.0 | -.6 | -.6 | -.4 | -.2 | -.1 | -.1 | -.1 | -.1 | .0 | .0 | .0 | .0 |
| 22.5 | -2.4 | -2.2 | -1.6 | -.8 | -.6 | -.5 | -.3 | -.2 | -.2 | -.2 | -.2 | -.1 | -.1 | -.3 | -.4 | -.4 |
| 20.0 | -2.0 | -1.8 | -1.4 | -.7 | -.4 | -.3 | -.2 | -.1 | -.1 | -.1 | -.1 | -.1 | -.1 | -.1 | -.2 | -.2 |
| 17.5 | -1.6 | -1.4 | -.9 | -.4 | .0 | .1 | .1 | .1 | .2 | .2 | .1 | .1 | .1 | .1 | .1 | .1 |
| 15.0 | -1.4 | -1.0 | -.4 | .1 | .3 | .4 | .5 | 1.0 | 1.8 | .7 | .4 | .1 | .1 | .1 | .1 | .1 |
| 12.5 | -1.0 | -.6 | -.2 | .2 | .7 | 1.0 | 1.4 | 1.2 | 2.0 | .7 | .4 | .1 | .1 | .1 | .1 | .1 |
| 10.0 | -.8 | -.6 | -.2 | .2 | 1.0 | 1.8 | 1.6 | .4 | 1.6 | .3 | .1 | .1 | .1 | .1 | .1 | .1 |
| 7.5 | -.7 | -.6 | -.4 | -.2 | .3 | .6 | .5 | .4 | .4 | .1 | -.1 | -.1 | -.1 | .0 | .0 | .0 |
| 5.0 | -.5 | -.4 | -.3 | -.2 | -.1 | .0 | .1 | .2 | .3 | .1 | -.1 | -.2 | -.1 | -.1 | .0 | .0 |
| 2.5 | -.3 | -.3 | -.2 | -.2 | -.2 | -.1 | .0 | .1 | .2 | .1 | -.2 | -.2 | -.2 | -.1 | .0 | .0 |

TABLE 3. Transient eddy ozone flux over western North America. Positive denotes northward. Units: $10^{18}$ molecules $m^{-2} sec^{-1}$.

SEASON: December - February

| km | 65N | 60 | 55 | 50 | 45 | 40 | 35 |
|---|---|---|---|---|---|---|---|
| 30.0 | 4.5 | 2.0 | -.5 | -.5 | -.2 | -.1 | -.1 |
| 27.5 | 4.5 | 1.6 | -.6 | -.5 | -.2 | -.1 | -.1 |
| 25.0 | 4.8 | 2.2 | -.5 | -.5 | -.3 | -.2 | -.2 |
| 22.5 | 4.5 | 2.2 | .0 | -.3 | -.3 | -.2 | -.3 |
| 20.0 | 4.0 | 2.2 | .0 | -.5 | -.4 | .2 | -.5 |
| 17.5 | 3.5 | 2.2 | -.1 | -1.0 | -.8 | 1.2 | -.5 |
| 15.0 | 3.1 | 2.1 | .0 | -.6 | .2 | 2.2 | .7 |
| 12.5 | 2.3 | 1.8 | 1.0 | .1 | .9 | 4.1 | .8 |
| 10.0 | 1.3 | 1.1 | .2 | -.8 | .8 | 3.0 | -.4 |
| 7.5 | .1 | -.2 | -.2 | -.7 | -.2 | .8 | -.8 |
| 5.0 | -.4 | -.3 | -.2 | -.2 | -.2 | .0 | -.1 |
| 2.5 | -.1 | -.1 | -.1 | -.1 | -.1 | -.1 | -.1 |

SEASON: March - May

| km | 65N | 60 | 55 | 50 | 45 | 40 | 35 |
|---|---|---|---|---|---|---|---|
| 30.0 | -1.7 | -1.0 | -.2 | .3 | 1.0 | .5 | -.5 |
| 27.5 | -2.0 | -1.1 | -.5 | .1 | .8 | 1.1 | -.1 |
| 25.0 | -2.0 | -1.4 | -.8 | -.3 | .4 | 1.0 | .2 |
| 22.5 | -2.3 | -1.8 | -1.2 | -.7 | -.1 | .4 | .2 |
| 20.0 | -2.8 | -2.2 | -1.6 | -.9 | -.4 | .0 | .0 |
| 17.5 | -3.2 | -2.7 | -2.2 | -1.5 | -1.2 | -1.2 | -1.0 |
| 15.0 | -3.2 | -2.7 | -2.0 | -1.2 | -.3 | -1.0 | -1.3 |
| 12.5 | -1.0 | -1.1 | -1.3 | .4 | 1.4 | 1.9 | .0 |
| 10.0 | 4.2 | 2.3 | -.4 | -2.1 | -.7 | 3.0 | .8 |
| 7.5 | 1.3 | .8 | .3 | .2 | .2 | .2 | .2 |
| 5.0 | .3 | .3 | .3 | .4 | .3 | -.1 | .1 |
| 2.5 | .1 | .1 | .1 | .1 | .0 | -.1 | .0 |

SEASON: June - August

| km | 65N | 60 | 55 | 50 | 45 | 40 | 35 |
|---|---|---|---|---|---|---|---|
| 30.0 | .4 | .3 | .2 | .2 | .2 | .1 | .1 |
| 27.5 | .4 | .3 | .2 | .2 | .2 | .1 | .1 |
| 25.0 | .3 | .3 | .3 | .2 | .1 | .1 | .0 |
| 22.5 | .3 | .3 | .3 | .2 | .1 | .0 | -.1 |
| 20.0 | .2 | .3 | .3 | .2 | .0 | -.1 | .0 |
| 17.5 | .2 | .2 | .1 | -.1 | [illegible] | -.4 | .2 |
| 15.0 | .3 | .1 | -.2 | -.4 | -.4 | .0 | 2.0 |
| 12.5 | .7 | .2 | -.2 | -1.0 | -.8 | 1.8 | 1.0 |
| 10.0 | 1.2 | .7 | -.2 | -1.1 | -1.0 | .0 | .0 |
| 7.5 | .4 | .3 | .1 | -.6 | -1.2 | -.4 | -.2 |
| 5.0 | .2 | .2 | .1 | -.2 | -.5 | -.4 | -.0 |
| 2.5 | .1 | .1 | .1 | .0 | -.1 | .0 | .1 |

SEASON: September - November

| km | 65N | 60 | 55 | 50 | 45 | 40 | 35 |
|---|---|---|---|---|---|---|---|
| 30.0 | -.2 | -.1 | -.1 | .0 | .0 | 1 | .1 |
| 27.5 | -.1 | -.2 | -.3 | 3 | .0 | .1 | .2 |
| 25.0 | .0 | -.2 | -.3 | [illegible] | -.5 | .1 | .4 |
| 22.5 | .0 | -.1 | -.2 | -.3 | -.3 | -.2 | .3 |
| 20.0 | .1 | .0 | -.3 | .0 | .0 | -.1 | .1 |
| 17.5 | .4 | .0 | -.7 | .0 | .0 | .0 | .2 |
| 15.0 | .8 | .2 | -1.0 | -1.0 | -.2 | 1.2 | -.2 |
| 12.5 | 1.8 | .7 | .1 | -1.2 | -.5 | 2.1 | -.2 |
| 10.0 | 1.1 | .8 | .4 | -.2 | -.2 | 2.1 | .2 |
| 7.5 | .0 | .2 | .2 | -.2 | -.2 | .5 | .3 |
| 5.0 | -.3 | -.2 | -.2 | -.2 | -.2 | -.2 | -.1 |
| 2.5 | -.3 | -.2 | -.1 | -.3 | -.3 | -.1 | -.1 |

TABLE 4. Transient eddy ozone flux over western Europe. Positive denotes northward. Units: $10^{18}$ molecules $m^{-2}sec^{-1}$.

SEASON: December - February

| km | 55N | 50 | 45 | 40 | 35 |
|---|---|---|---|---|---|
| 30.0 | -.4 | -.3 | -.2 | -.2 | .0 |
| 27.5 | -.3 | -.2 | -.1 | .2 | .5 |
| 25.0 | -.1 | .0 | .2 | .5 | .4 |
| 22.5 | 1.0 | 1.0 | .5 | .3 | .3 |
| 20.0 | 1.2 | 1.2 | 1.1 | .7 | .3 |
| 17.5 | 1.2 | 1.2 | 1.2 | 1.2 | .8 |
| 15.0 | 1.3 | 1.3 | 1.4 | 1.6 | 1.5 |
| 12.5 | 1.9 | 2.2 | 3.0 | 2.8 | 2.0 |
| 10.0 | [illegible] | 2.0 | 2.2 | 1.7 | .9 |
| 7.5 | -.2 | .0 | .2 | .2 | -.1 |
| 5.0 | -.5 | .0 | .1 | .0 | -.2 |
| 2.5 | -.3 | .0 | .1 | .0 | -.2 |

SEASON: March - May

| km | 55N | 50 | 45 | 40 | 35 |
|---|---|---|---|---|---|
| 30.0 | .4 | .3 | .2 | .2 | .2 |
| 27.5 | .2 | .2 | .2 | .2 | .2 |
| 25.0 | .0 | .0 | .0 | -.1 | -.1 |
| 22.5 | -.4 | -.4 | -.4 | -.3 | -.2 |
| 20.0 | -1.0 | -1.2 | -1.3 | -.5 | -.3 |
| 17.5 | -1.2 | -1.1 | -.8 | -.3 | -.2 |
| 15.0 | -.2 | .2 | .2 | -.2 | -.2 |
| 12.5 | 1.6 | 1.2 | .3 | -.2 | -.3 |
| 10.0 | 1.6 | 1.6 | .4 | -.3 | -.6 |
| 7.5 | .8 | .7 | .2 | -.2 | -.6 |
| 5.0 | .3 | .3 | .2 | -.2 | -.4 |
| 2.5 | .1 | .1 | .1 | -.1 | -.2 |

SEASON: June - August

| km | 55N | 50 | 45 | 40 | 35 |
|---|---|---|---|---|---|
| 30.0 | .1 | .1 | .1 | .1 | .1 |
| 27.5 | .2 | .2 | .1 | .1 | .1 |
| 25.0 | .3 | .2 | .1 | .1 | .1 |
| 22.5 | .2 | .1 | .1 | .0 | .0 |
| 20.0 | .0 | -.1 | -.2 | -.2 | -.2 |
| 17.5 | -.2 | -.3 | -.6 | -.7 | -.4 |
| 15.0 | .1 | .1 | -.1 | -.2 | -.3 |
| 12.5 | 1.0 | 1.2 | 1.0 | .2 | .0 |
| 10.0 | 1.8 | 1.3 | .8 | .0 | -.3 |
| 7.5 | .5 | .5 | .1 | -.3 | -.4 |
| 5.0 | -.1 | -.1 | -.1 | -.3 | -.3 |
| 2.5 | -.1 | -.1 | -.1 | -.2 | -.2 |

SEASON: September - November

| km | 55N | 50 | 45 | 40 | 35 |
|---|---|---|---|---|---|
| 30.0 | .3 | .3 | .2 | .1 | .1 |
| 27.5 | -.1 | .1 | .2 | .4 | .7 |
| 25.0 | -.4 | -.2 | .2 | .5 | .7 |
| 22.5 | -.1 | .0 | .2 | .5 | .7 |
| 20.0 | .2 | .2 | .3 | .5 | .6 |
| 17.5 | .4 | .3 | .3 | .4 | .5 |
| 15.0 | 1.0 | .5 | .3 | .3 | .3 |
| 12.5 | 1.2 | 1.0 | .8 | .4 | .3 |
| 10.0 | 1.2 | .9 | .8 | .3 | .0 |
| 7.5 | .5 | .2 | -.1 | -.2 | -.2 |
| 5.0 | .2 | .0 | -.1 | -.2 | -.2 |
| 2.5 | .1 | .1 | .1 | .0 | .0 |

TABLE 5. Transient eddy ozone flux over Japan. Positive denotes northward. Units: $10^{18}$ molecules $m^{-2}sec^{-1}$.

SEASON: December - February

| km | 45N | 40 | 35 | 30 |
|---|---|---|---|---|
| 30.0 | .0 | -.2 | -.4 | -.4 |
| 27.5 | .1 | .0 | -.3 | -.3 |
| 25.0 | .2 | .0 | -.2 | -.3 |
| 22.5 | .2 | .0 | -.3 | -.7 |
| 20.0 | .2 | .0 | -.5 | -1.6 |
| 17.5 | .6 | .3 | -.5 | -2.0 |
| 15.0 | .7 | 1.5 | .5 | -.4 |
| 12.5 | -.2 | .4 | .7 | -.5 |
| 10.0 | -1.0 | -.2 | .4 | -.7 |
| 7.5 | -.5 | .0 | .2 | -.5 |
| 5.0 | -.2 | .0 | .2 | -.2 |
| 2.5 | -.2 | .0 | .2 | -.2 |

SEASON: March - May

| km | 45N | 40 | 35 | 30 |
|---|---|---|---|---|
| 30.0 | .2 | .2 | .1 | .1 |
| 27.5 | .2 | .2 | .2 | .1 |
| 25.0 | .2 | .2 | .2 | .1 |
| 22.5 | .1 | .1 | .1 | .0 |
| 20.0 | .0 | .0 | .0 | -.2 |
| 17.5 | -1.4 | -1.3 | -.7 | -.2 |
| 15.0 | -3.2 | -1.8 | -.9 | -.5 |
| 12.5 | -4.0 | -2.8 | -2.2 | -1.8 |
| 10.0 | -1.0 | -1.5 | -2.0 | -1.0 |
| 7.5 | -.4 | -.4 | -.1 | .1 |
| 5.0 | -.1 | -.1 | .2 | -.1 |
| 2.5 | -.1 | -.1 | -.1 | -.2 |

SEASON: June - August

| km | 45N | 40 | 35 | 30 |
|---|---|---|---|---|
| 30.0 | .1 | .1 | .1 | .1 |
| 27.5 | .1 | .1 | .1 | .1 |
| 25.0 | .2 | .1 | -.1 | -.1 |
| 22.5 | .1 | .1 | .0 | -.1 |
| 20.0 | .1 | .3 | .3 | -.3 |
| 17.5 | .3 | .3 | .2 | -.3 |
| 15.0 | 1.6 | 1.0 | .3 | .0 |
| 12.5 | 3.6 | 2.2 | .3 | .3 |
| 10.0 | 1.8 | .8 | .2 | .0 |
| 7.5 | .5 | .3 | .0 | -.1 |
| 5.0 | .3 | .1 | -.2 | -.2 |
| 2.5 | .2 | .1 | -.3 | -.3 |

SEASON: September - November

| km | 45N | 40 | 35 | 30 |
|---|---|---|---|---|
| 30.0 | .3 | .2 | .0 | -.8 |
| 27.5 | .3 | .1 | -.3 | -.8 |
| 25.0 | .2 | -.1 | -.3 | -.5 |
| 22.5 | .0 | -.1 | -.2 | -.1 |
| 20.0 | .3 | .0 | -.4 | -.4 |
| 17.5 | .3 | .2 | -.2 | -.3 |
| 25.0 | .3 | .2 | -.1 | -.3 |
| 12.5 | 1.2 | .5 | -.2 | -.3 |
| 10.0 | 3.0 | 1.2 | -.2 | -.1 |
| 7.5 | .7 | .3 | -.2 | -.1 |
| 5.0 | .2 | .0 | -.1 | -.1 |
| 2.5 | .0 | .0 | .0 | -.2 |

## PART II

## EDDY DIFFUSION COEFFICIENTS AND WIND STATISTICS, 30-60 KM

### A. INTRODUCTION

The transport of trace substances in the atmosphere is effected by motion systems of widely varying space and time scales. In two-dimensional (height and latitude) atmospheric models, the transport by zonal mean meridional circulations is explicitly computed, while the transport by all other scales of motion is parameterized by eddy diffusion coefficients. Also, all models are calibrated and verified by comparing their output statistics with the observed atmospheric statistics. As models become more complex, statistics other than just the mean fields will be used for this purpose. For example, Cunnold, et al. (1975), found it useful to discuss the standard deviation of total ozone values, and future model results might be compared with other circulation statistics. The purpose of this report is to present seasonal estimates of all three components of the eddy diffusion matrix ($K_{yy}$, $K_{yz}$, $K_{zz}$) and of the means, variances, and covariances of wind and temperature at 30 to 60 km by latitude.

Previous efforts to estimate the individual components of the eddy diffusion matrix or the circulation statistics will be discussed as each set of results is presented. It will be noted here only that data above 30 km are limited to rocketsonde wind and temperature measurements and, recently, satellite measurements of radiance. Although the radiance data are useful for qualitative purposes, they cannot be directly interpreted as temperature measurements, and there are serious theoretical and practical problems in retrieving temperature profiles from them. Some authors (e.g., Hartman, 1977) have attempted to find temperature and wind fields from a relatively short period of radiance data, but there seems to be no widely accepted climatology of such data at this time. Thus, the rocket data are presently the only suitable base for estimating diffusion coefficients or circulation statistics above 30 km. Table 1 lists the rocket stations used in this study. Although the complete period of record used here was 1961-1976, the maximum number of years of suitable data for a given season at any station was 14 years and a typical number of years was about 11. These results are thus based on at least twice as many years of data as those of Kao, et al. (1978) (six years), Louis (1974) (four years), or Justus (1973) (six years).

Circulation statistics such as means and variances have been presented by many authors in the past. However, those results are scattered among different publications, have differing methods of data treatment and analysis, or use differing stations and periods of record. The circulation statistics presented here are the first results for both wind and temperature based on the same period of record and analyzed with the same technique for all results.

All rocketsonde data were obtained from WDC-A, Asheville, except for the stations near 70E during 1972-1976. The latter data were extracted from tabulations of rocket soundings along the Eastern Meridian Network obtained from NASA Wallops Space Flight Center. Throughout this report, three month seasons will be used with winter defined as December, January, and February.

## B. DIFFUSION COEFFICIENTS

### 1. $K_{yy}$

#### a. Method

From G. I. Taylor's theorem, the diffusion coefficient is equal to the product of the wind variance and the integral time scale. Murgatroyd (1969) used this theorem to obtain the meridional diffusion coefficient $K_{yy}$ by modeling the autocorrelation function as an exponentially damped cosine function of the time lag $\tau$. The model is given by

$$R(\tau) = e^{-\nu\tau}\cos\omega\tau, \tag{1}$$

with the parameters $\nu$ and $\omega$ obtained from wind trajectory data. The method of this report uses Murgatroyd's model with the parameters obtained by a least-squares fit to the calculated autocorrelation function for the meridional wind.

For each station and for each two kilometers from 30 km to 60 km, the sequence of daily wind values was high-pass filtered to remove seasonal trends and other very long-period variations associated with scales of motion not of interest. A 61 point Gaussian filter with a 50% response point at 28 days was used. The wind data are intermittent, and therefore to obtain an effective filter at least five points were required to be under the filter and the sum of filter weights was required to be at least .15. The filtered wind values were then divided into individual seasons for which the autocorrelation function was calculated out to a lag of 21 days. For larger lags, noise and insufficient data render meaningless the calculation of an autocorrelation function.

From the derived parameters, the Eulerian integral time scales were obtained and transformed to Lagrangian values by multiplying by .64, the value given by Murgatroyd for a height of 30 mb. The resulting integral time scales were multiplied by the meridional wind variances to give the meridional diffusion coefficients for each individual season. Finally, for each station and height, the values were averaged over all years to produce mean seasonal diffusion coefficients, $K_{yy}$. A standard error of estimate was calculated for each $K_{yy}$.

Because of the essential non-linearity of the model and the poor time distribution of some of the data, the least-squares routine failed to find parameter values for some of the individual seasons. This problem was very severe for stations along the Eastern Meridian Network. For these stations, observations are often taken only once a week making the calculation of an autocorrelation coefficient impossible. Only at Heiss Island during winter was the data sufficient to calculate $K_{yy}$ values.

### b. Errors

An estimate of the relative error in $K_{yy}$ is given by the ratio of the standard error of $K_{yy}$ to its mean value. This ratio varied considerably with station, season, and height, e.g., at Thule in winter from .5 at 30 km to 4.8 at 60 km, and at White Sands in winter from .4 at 30 km to .5 at 60 km. In summer, the corresponding ratios were .8 and 2.8 for Thule, and .4 and .5 for White Sands. In general, the relative error in $K_{yy}$ was about 50% at low and middle latitudes and about 100% at high latitudes.

### c. Results

An example of an autocorrelation function is given in Figure 1. The exponential damping is clearly present. However, a number of autocorrelation functions show an increase for lags of 10 to 15 days before damping toward zero, so in all cases the fitting was done only to lag 10.

The $K_{yy}$ values are given in Figure 2 and Table 2 for cross sections along 80W, 150W, and the average of the two meridians. Stations along 150W are more limited in latitudinal distribution than those stations along 80W. As a result, the mean cross section at very high and low latitudes is not an average but a repetition of the 80W $K_{yy}$ values for those latitudes. Figure 3 compares the winter $K_{yy}$ profile for Thule with that for Heiss Island. Though $K_{yy}$ values at Heiss Island are larger than those at Thule, the similarity of the profiles is obvious.

In winter, $K_{yy}$ values increase with latitude and generally with height (Figure 2). Largest values of $K_{yy}$ are found above 50 km along both 80W and 150W. Along 80W, a secondary maximum is located at about 35 km and 65N. A ridge of large values projects from high to middle latitudes with its axis between 50 and 52.5 km. During spring, $K_{yy}$ again generally increases with height and latitude. However, along 80W, a region of large values occurs over the equator at 60 km. $K_{yy}$ decreases in middle latitudes but increases again at high latitudes. The pattern of values tends to be more horizontal in summer. Along 80W, a wave-like pattern is present in the values with ridges around 15N and 45N. These ridges extend from 30 km to 60 km. However, they are not present in the 150W cross section. The autumn $K_{yy}$ pattern is similar to the spring pattern. Higher values of $K_{yy}$ occur at high latitudes and above 50 km, while a secondary maximum is present at 60 km over the equator.

### d. Discussion

Previous work on diffusion coefficients by Murgatroyd (1969) and others is nearly all limited to levels below 30 km and is not comparable to results in this report. However, Kao, et al., (1978) and Louis (1974) computed diffusion coefficients for a comparable region of the atmosphere. Though Kao, et al., did remove means and linear trends from the winds, neither they nor Louis removed seasonal and other long-period wind variations such as were removed by our high-pass filter. The emphasis in this study on the smaller scale diffusion process may account for much of the difference between present results and early work. Furthermore, because the wind variance in Kao, et al., is similar to our values, differences in $K_{yy}$ between the results of Kao, et al., and this report may be due to differences in the integral time scales.

In winter, the $K_{yy}$ values of Kao, et al., agree well with our values at low latitudes, but they are larger at high latitudes. Their maximum occurs at 45N near 30 km where it exceeds our value by about an order of magnitude. They do not show the maximum near 60 km where our values are larger by a factor of 4. On the other hand, Louis finds the maximum $K_{yy}$ at high latitudes near 50 km and low values near 30 km at all latitudes which agrees well with our results. In spring, our $K_{yy}$ pattern and that of Kao, et al., agree at low latitudes and heights. The values of Louis are much smaller and his results do not show a maximum at high latitudes. The summer wave-like pattern in $K_{yy}$ values is present in both our results and those of Kao, et al. However, our values near 55 km are about one-half of those of Kao. Louis does not show the wave-like pattern and his summer values are smaller by a factor of 3. The autumn pattern of $K_{yy}$ differs the most among the three results. We find maxima near 60 km at high latitudes and over the equator. Kao, et al., find no maxima in these regions but rather near 60N at 30-35 km. Louis' pattern consists of a horizontal band of large values stretching from the equator to the pole at 50 km. His $K_{yy}$ values are smaller than our results by a factor of 5.

2. $\underline{K_{yz}}$

a. Method

The method employed to calculate $K_{yz}$ is based on that of Reed and German (1965). The diffusion coefficient $K_{yz}$ is set proportional to the meridional diffusion coefficient $K_{yy}$, and the proportionality factor, $\alpha$, is the slope of the mixing path. In the middle troposphere, $\alpha$ is about one-half of the slope, $\beta$, of the isentropic surfaces. Wilcox (1976) computed the seasonal values of $\alpha$ and $\beta$ for tropospheric levels using heat flux data. Because the relationship between $\alpha$ and $\beta$ is not known for stratospheric levels, the method of this report uses the ratio of $\alpha$ to $\beta$ as computed by Wilcox for the approximately 26 km level at all levels.

The vertical and northward gradients of the isentropic surfaces were computed on a seasonal basis for each longitude. From these results, the ratio of the horizontal to the vertical potential temperature gradient was computed for each station, level, and season. The negative of this ratio was set equal to $\beta$, which was then multiplied by the ratio of $\alpha/\beta$, given by Wilcox, to give $\alpha$. The resulting $\alpha$ values were multiplied by the corresponding $K_{yy}$ values to give $K_{yz}$.

b. Errors

Because $K_{yz}$ depends directly upon $K_{yy}$, errors in $K_{yy}$ generate errors in $K_{yz}$. In addition, the ratio of $\alpha/\beta$ given by Wilcox was derived for conditions at about 26 km, but the ratio is used for all heights from 30 km to 60 km Therefore, considerable uncertainty, especially with regard to the sign of $K_{yz}$, is introduced at high altitudes. As a result, the error in $K_{yz}$ is at least as great as the error in $K_{yy}$, and could be larger.

c. Results

The values of $K_{yz}$ for 80W, 150W, and mean cross sections are given in Figure 4 and Table 3. As a reminder, the 150W cross section is limited in latitude and the mean cross section at high and low latitudes is not an average but a repetition of the 80W cross section. Also, no $K_{yz}$ are available for the Eastern Meridian Network because the data there were inadequate.

The $K_{yz}$ pattern for winter shows the largest positive values at 55 km and 40N with the largest negative values below and slightly poleward. This pattern of large positive values over large negative values is present at both 80W and 150W. In addition, there are a number of vertical bands of $K_{yz}$ alternating in sign which are located at lower latitudes. These vertical bands are probably due to the use of a constant $\alpha/\beta$ ratio at all heights. The largest values of $K_{yz}$ in these bands tend to be located near 60 km.

For the spring pattern, a large negative center is located near 60 km at 60N. This negative center projects downward and toward middle latitudes. In the lower latitudes, the alternating vertical bands of $K_{yz}$ are again present on the 80W and mean cross sections. For the 150W cross section, negative values dominate the middle and low latitudes. In summer, the pattern is simplified as poleward of 40N there are negative values at all heights, while equatorward the values are positive, except for a band of negative $K_{yz}$ values at 20N. The $K_{yz}$

pattern in autumn shows large positive values above 50 km at high latitudes and between 5N and 10N. Negative values are located at low levels in middle latitudes, at all heights south of the equator and above 45 km at 20N.

#### d. Discussion

Previous estimates of $K_{yz}$ above 30 km have been given by Louis, but extended to only 50 km. In winter, there is good agreement at high latitudes between our results and those of Louis. At middle and low latitudes, Louis found a larger area of weak positive values of $K_{yz}$, while our results produce a more detailed $K_{yz}$ structure with a large negative center at 50N and 50 km and negative regions scattered throughout the tropics.

In spring, there is good agreement between our results and those of Louis, except near 20N where we have a large negative area from 30 km to 60 km and Louis has weak positive values. At high and middle latitudes, we have a band of positive values extending from 45 km at 75N to 30 km at 50N, while Louis has weak negative values throughout the region. The summer patterns are very similar except at 20N where we have negative $K_{yz}$ values compared to Louis' positive values. Our autumn pattern is very dissimilar to that of Louis. We find large positive values above 50 km at high latitudes and sharply alternating regions above 45 km at low latitudes. In contrast, Louis has weak and uniform negative values at high latitudes and weak negative values at low latitudes.

General features for all seasons are the negative values at high latitudes and a region of large $K_{yz}$ values of contrasting sign from 15-20N at heights above 50 km. If the sign changes of $K_{yz}$ are real in this second region, these changes would indicate that significant eddy diffusion is occurring in this subtropical area.

### 3. Vertical Eddy Diffusion Coefficients ($K_{zz}$)

In the stratosphere, the vertical dispersion of material proceeds much slower than does the horizontal dispersion, and this will be reflected in the relative smallness of the $K_{zz}$ values presented below compared with the $K_{yy}$ or $K_{yz}$ values. Due to the high static stability of the stratosphere, convective overturning is suppressed and mechanical turbulence is confined to regions of very high wind shear. The shears associated with planetary scale waves or the mean circulation are not large enough to produce local instabilities. However, the relatively short vertical wavelengths of gravity waves can lead to unstable shears when the amplitude of the wave is sufficiently great. Hines (1970, 1974) has argued that the normal growth of wave amplitude with height arising from decreasing density will be offset by energy lost to turbulence, so the wave amplitude is constant with altitude. Based on this premise, Hines has developed a formalism to compute vertical diffusion coefficients.

According to Hines (1970), the vertical eddy diffusion coefficient is given by

$$K_D = 0.014\,\tau_g^{-1} H^{-1} \lambda_x^{4} \lambda_z^{4} (\lambda_x^{2} + \lambda_z^{2})^{-5/2} \qquad (2)$$

where $\tau_g$ is the Brunt-Vaisala period, H is the atmospheric density scale height, and $\lambda_x$ and $\lambda_z$ are the horizontal and vertical wavelengths of upward propograting gravity waves. In the case $\lambda_z \ll \lambda_x$ then equation (2) can be simplified (Justus, 1973) as

$$K_D = 0.014 \lambda_z^{4} (\tau_g H \lambda_x)^{-1} \qquad (3)$$

Zimmerman (1974) has argued that no amplitude growth is a poor approximation in the lower atmosphere. By balancing the vertical gradient of the specific wave energy with an effective turbulent viscosity he derived an alternate expression for the vertical component of K, which will be called $K_{zz}$ here:

$$K_{zz} = (\lambda_z^{3}/4\pi^{2}T) \{1/H - 1/Z \ln V^{2}/V_o^{2}\} \qquad (4)$$

where T is the period of the gravity wave, $V_o$ is the perturbation velocity at the reference level, and V is that at level Z.

If the kinetic energy of the gravity wave is decreasing according to

$$E = E_o \exp(-Z/h) \qquad (5)$$

then it can easily be shown that (4) is a modification to (3) as follows:

$$K_{zz} = (H/h)K_D \tag{6}$$

aside from the constant numerical factor. But Hines (1970) states that his numerical factor (0.014) was designed to give a predetermined result. Thus, the difference between 0.014 and the numerical factor in (4) ($1/4\pi^2 = 0.025$) is probably not important. In deriving (6) from (4), use is made of equation (34) of Hines (1974, paper 7), and the relations $E = 1/2\ \rho U^2$ and $\rho = \rho_o \exp(-Z/H)$.

In the case of no amplitude growth with height, then (6) shows that $K_{zz} = K_D$ because then H = h. In general, however, $K_{zz} < K_D$ because there is some aplitude growth with height. This is illustrated in Figure 5, where the growth of $V^2$ below 50 km causes the kinetic energy to fall off less rapidly than density (H<h), while above 50 km there is no amplitude growth so H = h.

Estimates of $K_{zz}$ given below were made using (4) after applying equation (34) of Hines (1974, paper 7). All available temperature and density data at each station were used to estimate $\tau_g$ and H for each season at 5 km height intervals. Estimates of $\lambda_z$ were made using the daily difference method described below. The ratios of $\lambda_x$ to $\lambda_z$ from the data given by Justus (1973) were used at all stations (Table 1) because the present data did not permit new estimates of $\lambda_x$. The error introduced by using constant values of $\lambda_x/\lambda_z$ should be very small, however, as $K_{zz}$ varies with the fourth power of $\lambda_z$ but only inversely with $\lambda_x$.

In the daily difference method, zonal and meridional wind data for soundings separated by 24 hours (± 15 minutes) in time are differenced on a level-by-level basis to resolve the gravity wave component of the data. As detailed in Justus and Woodrum (1972), this approach eliminates the seasonal, synoptic period, and tidal components of the winds. The vertical structure function, D(Z), of the differenced values was made for each sounding pair through 12 km intervals in height, centered 5 km apart, from 26 to 61 km. In each layer, a sounding pair was used only if all levels were present in the layer. The number of profiles (sounding pairs) available at 36-48 km is given in Table 1. Ideally, D(Z) should resemble a cycloid with wavelength $\lambda_z$. In practice, small-scale noise and a mixing of wavelengths combine to permit detection of only the average first maximum in D(Z), as illustrated in Figure 5. The half-wavelength was estimated from D(Z) by the location of the minimum of the second derivative with height.

Values of $K_{zz}$ for the stations along 80W, along about 150W, and for their mean are given in Figure 6 and Table 4. In general, $K_{zz}$ increases steadily from 30 km to the upper stratosphere, and usually increases very rapidly in the lower mesosphere, (note that the contours in Figure 6 are at non-uniform intervals). Although there are differences between the 80W and 150W sections, some persistent features emerge in the mean sections. For example, the trough of relatively small values with latitude near 25N in the upper stratosphere during winter is found near 60N in spring, 40N in summer, and 40N in autumn. In the mean sections, largest values are found in the tropical mesosphere during all seasons, and exceed 200 $m^2s^{-1}$ during winter and summer.

Statistical errors of $K_{zz}$ range from 15 to 55%, and average about 30% of the value of $K_{zz}$. Errors were estimated by a Monte Carlo simulation of D(Z), randomly allowing each point along D(Z) to be anywhere within one standard error of the mean value of D(Z). For each simulation a $\lambda_z$ was computed, and the standard error of the mean of the sample of $\lambda_z$'s was used in the differential form of equation (4) to estimate the error in $K_{zz}$.

At 55 km the present results are about three-fourths as large as the seasonal-latitudinal average value given by Justus (1973). His data are from all seasons and apparently represent the average of Ascension Island, Cape Kennedy, and Fort Greely for the period 1964-1969 (Justus and Woodrum, 1972). At 35 km the seasonal-latitudinal average of the present results is about 4 $m^2sec^{-1}$ while Justus gives about 20 $m^2sec^{-1}$. The present results are smaller than those of Justus because the adjustment factor presented in equation 6 is less than one at all levels on the average, and is smaller at 35 than at 55 km.

A new feature of the present results is the very rapid increase of $K_{zz}$ above the stratopause. Past workers have suggested a sudden decrease of $K_{zz}$ at the tropopause followed by a steady increase up to the mesopause. It now appears that there is a sudden increase at the stratopause.

## C. CIRCULATION STATISTICS

All mean values presented here were computed by arithmetically averaging all available observations for a given season and level at each station. Variances and covariances were computed using data high-pass filtered with the filter described in Section B.

### 1. Seasonal Means and Variances

#### a. Temperature

Temperature data for all stations listed in Table 1 were used to prepare the results presented in Figures 7-8 and Tables 5-6. Data at stations near 60E were ignored above 50 km because they are not compatible with other data at high altitudes (Finger, et al., 1975). Corrections for solar radiation errors were applied to observations flagged as not already corrected, as described in Nastrom and Belmont (1974).

During all seasons, the mean stratopause slopes upward toward the pole (Figure 7), but has mean temperatures above 270K at all latitudes only during spring. Variance of temperature (Figure 8) is largest during winter near 60N. During spring, largest variances are found at highest latitudes below 45 km, while during autumn the maximum variance is near 60 km at 60N. Largest variance during summer occurs in the lower mesosphere near 30N.

#### b. Zonal wind speed

The winter jet in mean zonal wind speed (Figure 9 and Table 7) is found above 55 km near 40N, in agreement with past results (Belmont, et al., 1975; Taresenko, et al., 1976). Other features of the mean zonal flow are also well-known and serve to verify past results. One interesting feature which cannot be shown in seasonal mean sections is the quasi-biennial oscillation (QBO), which is largest below about 30 km equatorward of about $20^{o}$ latitude (Belmont, et al., 1975). Due to the QBO, mean values in the tropical mid-stratosphere depend strongly on the period of record chosen for averaging. Finally, it should be noted that no attempt has been made to reconcile the mean zonal winds and the mean temperatures via the thermal wind relation. The available stations (Table 1) do not permit making true zonal means, and even along given longitudes the stations do not lie along a straight north-south line and only approximate a meridional section. Also, stations don't all take their observations at the same time. Station distribution, observational incongruities, and other sampling problems can lead to model dynamic instability, such as found by Schoeberl and Zalesak (1976) for the CIRA (1972) zonal wind model despite the care taken to make it obey the thermal wind relation.

The variances of zonal wind speed (Figure 10 and Table 8) generally follow the same pattern as the variances of temperature. It should be noted that the present results represent wind variability due only to high frequency variations and do not include interannual or other long-period changes.

### c. Meridional wind speed along 80W

The seasonal mean values of meridional wind speed given in Figure 11 and Table 9 verify the patterns previously published for mid-seasonal months (Nastrom, et al., 1975). As stressed in the latter paper, the mean meridional winds at a given location are largely due to standing planetary waves. Thus, the mean value is a strong function of longitude so that a dense network of stations would be required to resolve the zonal mean value.

The variances of meridional wind speed, which were used in Section B for estimating $K_{yy}$, are given in Figure 12 and Table 10. Largest variances are found near the polar stratopause during all seasons except summer, when the largest values are in the tropical mesosphere. These results should not be compared with previous values (e.g., Newell, et al., 1966) which failed to remove the interannual component of the variance. As shown in Nastrom, et al. (1975, Table 2), the variance due to interannual variations is about the same magnitude as the high-frequency component presented here.

## 2. Seasonal Covariances

The covariances of the (high-pass filtered) meridional wind with zonal wind and temperature are presented in Figure 13 and 14 and Tables 11 and 12.

These represent the poleward fluxes of westerly momentum and temperature (sensible heat) by the transient eddies. In preparing these results, data for all stations were plotted, but stations nearest 80W were favored during the analysis if longitudinal differences were found. For example, during winter at 40 km the covariance of wind and temperature at Heiss is large positive while at Thule it is large negative, and so the final analysis shows negative values. Also, these results do not represent the fluxes by standing waves. Although there have been efforts (e.g., Stanford and Dunkerton, 1978) to estimate winds and temperatures from satellite data on a global basis, a useful climatology of such data is not yet available to compute standing eddy fluxes. Thus, there is no way to measure the relative importance of transient and standing eddy fluxes.

## D. SUMMARY

In view of the differing analysis techniques or differing data samples, the eddy diffusivities presented here agree remarkably well with past estimates. However, in the application of K-values to two-dimensional models the actual magnitude of the diffusivities is no more important than their spatial patterns, i.e., their gradients with height and latitude. As the present patterns are often much different from those of past results (and from each other, depending on longitude), these diffusivities are expected to influence future model results.

The circulation statistics presented here confirm and expand on the numerous past results given, usually, for each parameter separately or for a relatively short period of record. It seems that these covariances of meridional wind with temperature and zonal wind are the first complete set of such results to be presented.

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TABLE 1. Rocketsonde data used, 1961-1976 (at 50 km).

| Station | LAT | LON | Number of data pairs at lag zero (for $K_{yy}$ & $K_{yz}$) SPR | SUM | AUT | WIN | Number of sounding pairs (for $K_{zz}$) SPR | SUM | AUT | WIN |
|---|---|---|---|---|---|---|---|---|---|---|
| a. Stations near 80°W (Atlantic zone) | | | | | | | | | | |
| Thule | 77 | 69 | 137 | 188 | 122 | 61 | 21 | 30 | 25 | 17 |
| Churchill | 59 | 94 | 316 | 235 | 229 | 357 | 43 | 17 | 74 | 113 |
| Wallops | 38 | 75 | 399 | 460 | 277 | 301 | 27 | 29 | 40 | 33 |
| White Sands | 32 | 106 | 748 | 672 | 574 | 598 | 97 | 72 | 91 | 118 |
| Canaveral | 28 | 81 | 518 | 623 | 478 | 438 | 141 | 102 | 93 | 160 |
| Antigua | 17 | 62 | 183 | 92 | 124 | 160 | 2 | 3 | 2 | 5 |
| Sherman | 8 | 80 | 276 | 271 | 201 | 207 | 51 | 37 | 25 | 36 |
| Ascension | -8 | 14 | 437 | 438 | 477 | 283 | 72 | 51 | 35 | 57 |
| b. Stations near 150°W (Pacific zone) | | | | | | | | | | |
| Poker Flats | 64 | 146 | 147 | 202 | 158 | 144 | 72 | 78 | 54 | 59 |
| Primrose | 55 | 110 | 172 | 58 | 194 | 94 | 6 | 4 | 8 | 10 |
| Point Mugu | 34 | 119 | 593 | 542 | 548 | 557 | 61 | 52 | 62 | 59 |
| Barking Sands | 22 | 160 | 557 | 445 | 441 | 355 | 141 | 131 | 112 | 102 |
| Kwajalein | 9 | -168 | 161 | 175 | 150 | 230 | 5 | 6 | 6 | 7 |
| c. Stations near 60°E | | | | | | | | | | |
| Heiss Island | 81 | -58 | 7 | 23 | 0 | 58 | 6 | 11 | 1 | 9 |
| Volgograd | 49 | -44 | 6 | 0 | 8 | 11 | 3 | 1 | 0 | 1 |
| Thumba | 8 | -77 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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TABLE 2. Seasonal values of $K_{yy}$ ($10^4$ m$^2$sec$^{-1}$).

SEASON: WINTER HORIZONTAL DIFFUSION COEFFICIENTS (K-YY) IN $10^4$ METERS SQUARED PER SECOND

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LONGITUDE: 80W | | | | | | | | | | | | | | | | | |
| 60.0 KM | 884 | 741 | 592 | 430 | 255 | 119 | 121 | 123 | 258 | 168 | 120 | 127 | 114 | 103 | 100 | 105 | 115 |
| 57.5 | 759 | 681 | 592 | 480 | 344 | 219 | 183 | 183 | 269 | 166 | 116 | 117 | 97 | 106 | 116 | 117 | 112 |
| 55.0 | 634 | 622 | 593 | 531 | 424 | 320 | 246 | 243 | 281 | 163 | 113 | 108 | 81 | 109 | 131 | 129 | 110 |
| 52.5 | 500 | 515 | 514 | 480 | 405 | 316 | 248 | 236 | 253 | 141 | 90 | 91 | 83 | 93 | 101 | 98 | 89 |
| 50.0 | 365 | 409 | 436 | 430 | 381 | 312 | 252 | 229 | 224 | 120 | 68 | 75 | 86 | 78 | 70 | 68 | 68 |
| 47.5 | 312 | 360 | 391 | 388 | 344 | 278 | 222 | 205 | 210 | 119 | 57 | 49 | 63 | 61 | 56 | 54 | 54 |
| 45.0 | 258 | 310 | 346 | 347 | 306 | 244 | 192 | 181 | 195 | 118 | 46 | 23 | 41 | 44 | 41 | 40 | 41 |
| 42.5 | 360 | 399 | 420 | 407 | 350 | 271 | 198 | 160 | 156 | 109 | 62 | 37 | 35 | 36 | 36 | 35 | 33 |
| 40.0 | 462 | 487 | 494 | 467 | 395 | 297 | 203 | 138 | 117 | 101 | 78 | 50 | 29 | 28 | 30 | 29 | 25 |
| 37.5 | 415 | 475 | 509 | 493 | 412 | 295 | 180 | 107 | 92 | 77 | 53 | 35 | 32 | 29 | 26 | 23 | 20 |
| 35.0 | 367 | 462 | 524 | 520 | 430 | 293 | 157 | 75 | 66 | 54 | 29 | 19 | 35 | 30 | 22 | 17 | 15 |
| 32.5 | 258 | 346 | 408 | 415 | 352 | 247 | 138 | 65 | 48 | 45 | 31 | 21 | 28 | 20 | 13 | 10 | 10 |
| 30.0 | 149 | 230 | 291 | 310 | 273 | 201 | 119 | 55 | 30 | 37 | 33 | 24 | 20 | 13 | 4 | 2 | 5 |
| LONGITUDE: 150W | | | | | | | | | | | | | | | | | |
| 60.0 KM | | | 541 | 461 | 386 | 322 | 267 | 223 | 188 | 162 | 145 | 135 | 133 | 135 | | | |
| 57.5 | | | 533 | 494 | 447 | 386 | 319 | 255 | 204 | 174 | 159 | 153 | 149 | 146 | | | |
| 55.0 | | | 524 | 527 | 507 | 450 | 370 | 260 | 219 | 185 | 174 | 171 | 165 | 156 | | | |
| 52.5 | | | 513 | 546 | 547 | 494 | 403 | 300 | 213 | 161 | 139 | 136 | 141 | 149 | | | |
| 50.0 | | | 502 | 566 | 588 | 538 | 436 | 315 | 206 | 137 | 104 | 101 | 116 | 143 | | | |
| 47.5 | | | 516 | 504 | 475 | 416 | 337 | 254 | 183 | 135 | 108 | 96 | 95 | 99 | | | |
| 45.0 | | | 531 | 443 | 362 | 294 | 239 | 194 | 159 | 133 | 111 | 92 | 74 | 56 | | | |
| 42.5 | | | 519 | 409 | 311 | 237 | 184 | 147 | 122 | 104 | 90 | 77 | 61 | 44 | | | |
| 40.0 | | | 507 | 374 | 260 | 179 | 128 | 99 | 84 | 76 | 70 | 62 | 49 | 33 | | | |
| 37.5 | | | 429 | 313 | 214 | 144 | 101 | 77 | 64 | 57 | 52 | 46 | 38 | 28 | | | |
| 35.0 | | | 352 | 252 | 167 | 109 | 74 | 55 | 45 | 39 | 34 | 30 | 27 | 23 | | | |
| 32.5 | | | 270 | 183 | 111 | 66 | 44 | 36 | 34 | 31 | 27 | 24 | 21 | 20 | | | |
| 30.0 | | | 188 | 113 | 54 | 22 | 13 | 17 | 22 | 23 | 20 | 17 | 16 | 17 | | | |
| LONGITUDE: MEAN | | | | | | | | | | | | | | | | | |
| 60.0 KM | 884 | 741 | 566 | 445 | 327 | 220 | 194 | 173 | 223 | 165 | 132 | 131 | 123 | 119 | 100 | 105 | 115 |
| 57.5 | 759 | 681 | 562 | 487 | 395 | 302 | 251 | 219 | 236 | 170 | 137 | 135 | 123 | 126 | 116 | 117 | 112 |
| 55.0 | 634 | 622 | 558 | 529 | 468 | 385 | 307 | 264 | 250 | 174 | 143 | 139 | 123 | 132 | 131 | 129 | 110 |
| 52.5 | 500 | 515 | 513 | 513 | 476 | 405 | 325 | 268 | 233 | 151 | 114 | 113 | 112 | 121 | 101 | 98 | 89 |
| 50.0 | 365 | 409 | 469 | 498 | 484 | 425 | 344 | 272 | 215 | 128 | 86 | 88 | 101 | 110 | 70 | 68 | 68 |
| 47.5 | 312 | 360 | 453 | 446 | 409 | 347 | 279 | 229 | 196 | 127 | 82 | 72 | 79 | 80 | 56 | 54 | 54 |
| 45.0 | 258 | 310 | 438 | 395 | 334 | 269 | 215 | 187 | 177 | 125 | 78 | 57 | 57 | 50 | 41 | 40 | 41 |
| 42.5 | 360 | 399 | 469 | 408 | 330 | 254 | 191 | 153 | 139 | 106 | 76 | 57 | 48 | 40 | 36 | 35 | 33 |
| 40.0 | 462 | 487 | 500 | 420 | 327 | 238 | 165 | 118 | 100 | 88 | 74 | 56 | 39 | 30 | 30 | 29 | 25 |
| 37.5 | 415 | 475 | 469 | 403 | 313 | 219 | 140 | 92 | 78 | 67 | 52 | 40 | 35 | 28 | 26 | 23 | 20 |
| 35.0 | 367 | 462 | 438 | 388 | 298 | 201 | 115 | 65 | 55 | 46 | 31 | 24 | 31 | 26 | 22 | 17 | 15 |
| 32.5 | 258 | 346 | 339 | 299 | 231 | 156 | 91 | 50 | 41 | 38 | 29 | 22 | 24 | 20 | 13 | 10 | 10 |
| 30.0 | 149 | 230 | 239 | 211 | 163 | 111 | 66 | 36 | [illegible] | 30 | 26 | 20 | 18 | 13 | 4 | 2 | 5 |

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TABLE 2. Seasonal values of $K_{yy}$ ($10^4$ $m^2 sec^{-1}$).

SEASON: SPRING HORIZONTAL DIFFUSION COEFFICIENTS (K-YY) IN $10^4$ METERS SQUARED PER SECOND

LONGITUDE: 80W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 270 | 223 | 175 | 125 | 74 | 36 | 27 | 63 | 113 | 54 | 53 | 89 | 107 | 151 | 174 | 167 | 140 |
| 57.5 | 296 | 231 | 168 | 113 | 69 | 42 | 38 | 65 | 97 | 52 | 40 | 66 | 95 | 112 | 115 | 106 | 91 |
| 55.0 | 322 | 238 | 162 | 102 | 64 | 47 | 49 | 66 | 81 | 50 | 27 | 42 | 83 | 73 | 56 | 46 | 42 |
| 52.5 | 235 | 199 | 163 | 128 | 96 | 69 | 55 | 58 | 70 | 49 | 38 | 45 | 59 | 58 | 52 | 46 | 41 |
| 50.0 | 148 | 160 | 164 | 155 | 127 | 91 | 61 | 51 | 59 | 49 | 49 | 48 | 35 | 42 | 48 | 47 | 41 |
| 47.5 | 131 | 135 | 134 | 124 | 101 | 74 | 53 | 48 | 57 | 50 | 52 | 51 | 35 | 37 | 41 | 40 | 36 |
| 45.0 | 113 | 110 | 104 | 93 | 76 | 58 | 45 | 46 | 55 | 50 | 55 | 54 | 34 | 31 | 33 | 33 | 31 |
| 42.5 | 109 | 103 | 96 | 84 | 67 | 50 | 39 | 38 | 46 | 46 | 52 | 49 | 27 | 24 | 26 | 26 | 25 |
| 40.0 | 104 | 96 | 87 | 75 | 59 | 43 | 32 | 30 | 36 | 41 | 48 | 43 | 20 | 17 | 19 | 20 | 20 |
| 37.5 | 108 | 95 | 87 | 76 | 61 | 44 | 31 | 26 | 30 | 32 | 32 | 28 | 19 | 20 | 22 | 21 | 19 |
| 35.0 | 96 | 93 | 87 | 77 | 62 | 44 | 38 | 22 | 23 | 24 | 16 | 12 | 18 | 24 | 25 | 23 | 19 |
| 32.5 | 72 | 81 | 86 | 82 | 67 | 46 | 27 | 18 | 19 | 18 | 15 | 13 | 13 | 18 | 20 | 19 | 16 |
| 30.0 | 48 | 70 | 85 | 87 | 72 | 48 | 25 | 13 | 15 | 12 | 13 | 14 | 8 | 12 | 15 | 15 | 12 |

LONGITUDE: 150W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | | | 243 | 194 | 158 | 143 | 143 | 147 | 144 | 127 | 105 | 91 | 93 | 104 | | | |
| 57.5 | | | 190 | 169 | 150 | 136 | 125 | 115 | 106 | 95 | 85 | 77 | 74 | 74 | | | |
| 55.0 | | | [illegible] | 144 | 143 | 129 | 107 | 84 | 67 | 43 | 64 | 64 | 56 | 44 | | | |
| 52.5 | | | 126 | 113 | 99 | 66 | 73 | 63 | 58 | 57 | 58 | 58 | 53 | 46 | | | |
| 50.0 | | | 115 | 82 | 56 | 42 | 39 | 43 | 48 | 51 | 52 | 52 | 50 | 48 | | | |
| 47.5 | | | [illegible] | 93 | 64 | 49 | 45 | 47 | 51 | 51 | 46 | 45 | 42 | 39 | | | |
| 45.0 | | | 144 | 104 | 72 | 56 | 51 | 52 | 53 | 50 | 44 | [illegible] | 33 | 30 | | | |
| 42.5 | | | 116 | 86 | 62 | 48 | 42 | 41 | 42 | 42 | 40 | 36 | 31 | 26 | | | |
| 40.0 | | | 89 | 69 | 52 | 40 | 33 | 31 | 31 | 34 | 36 | 35 | 30 | 22 | | | |
| 37.5 | | | 72 | 58 | 46 | 37 | 31 | 28 | 26 | 27 | 27 | 27 | 23 | 17 | | | |
| 35.0 | | | 55 | 48 | 41 | 35 | 29 | 24 | 21 | 20 | 19 | 18 | 16 | 13 | | | |
| 32.5 | | | 55 | 46 | 39 | 31 | 25 | 20 | 17 | 15 | 15 | 14 | 13 | 11 | | | |
| 30.0 | | | 54 | 45 | 36 | 28 | 21 | 16 | 13 | 11 | 11 | 10 | 10 | 9 | | | |

LONGITUDE: MEAN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 270 | 223 | 209 | 159 | 116 | 39 | 85 | 165 | 128 | 98 | 79 | 98 | 100 | 127 | 174 | 167 | 140 |
| 57.5 | 296 | 231 | 179 | 141 | 109 | 89 | 81 | 98 | 101 | 73 | 62 | 71 | 84 | 93 | 115 | 106 | 91 |
| 55.0 | 322 | 238 | 149 | 123 | 103 | 88 | 78 | 75 | 74 | 56 | 45 | 53 | 69 | 58 | 56 | 46 | 42 |
| 52.5 | 235 | 199 | 144 | 120 | 97 | 77 | 84 | 60 | 64 | 53 | 48 | 51 | 56 | 52 | 52 | 46 | 41 |
| 50.0 | 148 | 160 | 139 | 118 | 91 | 66 | 50 | 47 | 53 | 50 | 50 | 50 | 42 | 45 | 48 | 47 | 41 |
| 47.5 | 131 | 135 | 132 | 108 | 82 | 61 | 49 | 47 | 54 | 50 | 50 | 48 | 38 | 38 | 41 | 40 | 36 |
| 45.0 | 113 | 110 | 124 | 98 | 74 | 57 | 48 | 49 | 54 | 50 | 49 | 45 | 33 | 30 | 33 | 33 | 31 |
| 42.5 | 109 | 103 | 106 | 85 | 64 | 49 | 40 | 39 | 44 | 44 | 46 | 42 | 29 | 25 | 26 | 26 | 25 |
| 40.0 | 104 | 96 | 88 | 72 | 55 | 41 | 32 | 30 | 33 | [illegible] | 42 | 39 | 25 | 19 | 19 | 20 | 20 |
| 37.5 | 100 | 95 | 79 | 67 | 53 | [illegible] | 31 | 27 | 28 | 29 | 29 | 27 | 21 | 18 | 22 | 21 | 19 |
| 35.0 | 96 | 93 | 71 | 62 | 51 | 39 | 29 | 23 | 22 | 22 | 17 | 15 | 17 | 18 | 25 | 23 | 19 |
| 32.5 | 72 | 81 | 70 | 64 | 53 | 38 | 26 | 19 | 18 | 16 | 15 | 13 | 13 | 14 | 20 | 19 | 16 |
| 30.0 | 48 | 70 | 69 | 66 | 54 | 38 | 23 | 14 | 14 | 11 | 12 | 12 | 9 | 10 | 15 | 15 | 12 |

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TABLE 2. Seasonal values of $K_{yy}$ ($10^4\ m^2 sec^{-1}$).

SEASON:SUMMER HORIZONTAL DIFFUSION COEFFICIENTS (K-YY) IN $10^4$ METERS SQUARED PER SECOND

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LONGITUDE: 80W | | | | | | | | | | | | | | | | | |
| 60.0 KM | 193 | 137 | 91 | 64 | 61 | 75 | 94 | 105 | 103 | 106 | 120 | 129 | 140 | 210 | 246 | 232 | 185 |
| 57.5 | 118 | 93 | 72 | 57 | 51 | 54 | 65 | 83 | 99 | 93 | 93 | 91 | 91 | 138 | 165 | 160 | 133 |
| 55.0 | 43 | 49 | 53 | 50 | 40 | 32 | 35 | 60 | 95 | 80 | 55 | 54 | 43 | 67 | 85 | 88 | 81 |
| 52.5 | 35 | 40 | 43 | 42 | 36 | 30 | 32 | 47 | 70 | 62 | 51 | 44 | 45 | 64 | 76 | 77 | 70 |
| 50.0 | 26 | 30 | 33 | 33 | 31 | 28 | 28 | 35 | 45 | 44 | 36 | 35 | 47 | 62 | 68 | 66 | 59 |
| 47.5 | 22 | 24 | 26 | 26 | 23 | 20 | 20 | 25 | 36 | 42 | 37 | 32 | 38 | 48 | 53 | 54 | 52 |
| 45.0 | 18 | 19 | 19 | 18 | 15 | 12 | 12 | 16 | 27 | 40 | 38 | 30 | 28 | 33 | 39 | 42 | 44 |
| 42.5 | 15 | 16 | 16 | 14 | 10 | 7 | 7 | 13 | 25 | 31 | 31 | 27 | 22 | 27 | 33 | 37 | 39 |
| 40.0 | 12 | 13 | 12 | 10 | 5 | 1 | 2 | 10 | 23 | 23 | 24 | 24 | 16 | 21 | 28 | 32 | 34 |
| 37.5 | 12 | 13 | 12 | 10 | 6 | 1 | 1 | 8 | 19 | 18 | 19 | 18 | 14 | 20 | 26 | 23 | 28 |
| 35.0 | 12 | 13 | 12 | 10 | 6 | 2 | 0 | 5 | 14 | 14 | 13 | 13 | 12 | 19 | 23 | 24 | 21 |
| 32.5 | 11 | 10 | 10 | 8 | 5 | 2 | 1 | 4 | 11 | 11 | 12 | 12 | 10 | 17 | 22 | 22 | 20 |
| 30.0 | 9 | 8 | 7 | 5 | 3 | 1 | 1 | 3 | 8 | | 12 | 11 | 7 | 14 | 20 | 21 | 18 |
| LONGITUDE: 150W | | | | | | | | | | | | | | | | | |
| 60.0 KM | | | 67 | 59 | 57 | 66 | 81 | 94 | 97 | 87 | 72 | 61 | 65 | 77 | | | |
| 57.5 | | | 59 | 62 | 67 | 73 | 79 | 83 | 81 | 73 | [illegible] | 57 | 58 | 65 | | | |
| 55.0 | | | 50 | 66 | 77 | 80 | 78 | 72 | 65 | 59 | 54 | 52 | 52 | 53 | | | |
| 52.5 | | | 40 | 50 | 58 | 60 | 58 | 54 | 49 | 46 | 44 | 43 | [illegible] | 42 | | | |
| 50.0 | | | 29 | 35 | 39 | 40 | 39 | 36 | 34 | 34 | 34 | 34 | 32 | 30 | | | |
| 47.5 | | | 23 | 27 | 29 | 30 | 30 | 29 | 29 | 31 | 33 | 35 | 36 | 36 | | | |
| 45.0 | | | 17 | 18 | 19 | 20 | 21 | 22 | 25 | 28 | 32 | 36 | 39 | 42 | | | |
| 42.5 | | | 13 | 15 | 17 | 18 | 19 | 19 | 20 | 22 | 24 | 26 | 27 | 28 | | | |
| 40.0 | | | 8 | 12 | 15 | 16 | 16 | 16 | 15 | 16 | 17 | 17 | 16 | 14 | | | |
| 37.5 | | | 7 | 11 | 14 | 15 | 14 | 13 | 12 | 12 | 12 | 12 | 12 | 12 | | | |
| 35.0 | | | 6 | 10 | 12 | 13 | 12 | 10 | 8 | 7 | 7 | 8 | 9 | 10 | | | |
| 32.5 | | | 5 | 7 | 8 | 8 | 8 | 8 | 7 | 6 | 6 | 6 | 7 | 8 | | | |
| 30.0 | | | 5 | 4 | 3 | 3 | 4 | 5 | 6 | 6 | 5 | 5 | 5 | 5 | | | |
| LONGITUDE: MEAN | | | | | | | | | | | | | | | | | |
| 60.0 KM | 193 | 137 | 79 | 61 | 59 | 70 | 87 | 99 | 100 | 96 | 96 | 95 | 102 | 143 | 246 | 232 | 185 |
| 57.5 | 118 | 93 | 65 | 59 | 59 | 63 | 72 | 83 | 90 | 83 | 78 | 74 | 74 | 101 | 165 | 160 | 133 |
| 55.0 | 43 | 49 | 51 | 58 | 58 | 56 | 56 | 66 | 80 | 69 | 59 | 53 | 47 | 60 | 85 | 88 | 81 |
| 52.5 | 35 | 40 | 41 | 46 | 47 | 45 | 45 | 50 | 59 | 54 | 47 | 43 | 43 | 53 | 76 | 77 | 70 |
| 50.0 | 26 | 30 | 31 | 34 | 35 | 34 | 33 | 35 | 39 | 39 | 35 | 34 | 39 | 46 | 68 | 66 | 59 |
| 47.5 | 22 | 24 | 24 | 26 | 26 | 25 | 25 | 27 | 32 | 36 | 35 | 33 | 37 | 42 | 53 | 54 | 52 |
| 45.0 | 18 | 19 | 18 | 18 | 17 | 16 | 16 | 19 | 26 | 34 | 35 | 33 | 33 | 37 | 39 | 42 | 44 |
| 42.5 | 15 | 16 | 14 | 14 | 13 | 12 | 13 | 16 | 22 | 26 | 27 | 26 | 24 | 27 | 33 | 37 | 39 |
| 40.0 | 12 | 13 | 10 | 11 | 10 | 8 | 9 | 13 | 19 | 19 | 20 | 20 | 16 | 17 | 28 | 32 | 34 |
| 37.5 | 12 | 13 | 9 | 10 | 10 | 8 | 7 | 10 | 15 | 15 | 15 | 15 | 13 | 16 | 26 | 28 | 28 |
| 35.0 | 12 | 13 | 9 | 10 | 9 | 7 | 6 | 7 | 11 | 10 | 10 | 10 | 10 | 14 | 23 | 24 | 21 |
| 32.5 | 11 | 10 | 7 | 7 | 6 | 5 | 4 | 6 | 9 | 8 | 9 | 9 | 8 | 12 | 22 | 22 | 20 |
| 30.0 | 9 | 8 | 6 | 4 | 3 | 2 | 2 | 4 | 7 | 7 | 8 | 8 | 6 | 9 | 20 | 21 | 18 |

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TABLE 2. Seasonal values of $K_{yy}$ ($10^4$ $m^2 sec^{-1}$).

SEASON:AUTUMN HORIZONTAL DIFFUSION COEFFICIENTS (K-YY) IN $10^4$ METERS SQUARED PER SECOND

LONGITUDE: 80W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 792 | 628 | 472 | 333 | 221 | 145 | 116 | 144 | 199 | 160 | 144 | 127 | 111 | 269 | 359 | 332 | [illegible] |
| 57.5 | 635 | 528 | 423 | 323 | 231 | 161 | 126 | 139 | 177 | 137 | 125 | 125 | 115 | 186 | 222 | 202 | 144 |
| 55.0 | 479 | 428 | 374 | 312 | 242 | 177 | 135 | 133 | 154 | 113 | 106 | 123 | 119 | 103 | 86 | 71 | 58 |
| 52.5 | 393 | 374 | 344 | 290 | 210 | 130 | 84 | 104 | 160 | 109 | 86 | 56 | 88 | 68 | 54 | 46 | 44 |
| 50.0 | 307 | 320 | 313 | 269 | 179 | 83 | 32 | 76 | 177 | 104 | 65 | 69 | 57 | 33 | 21 | 21 | 30 |
| 47.5 | 300 | 293 | 275 | 230 | 176 | 111 | 71 | 83 | 131 | 94 | 62 | 51 | 44 | 32 | 25 | 25 | 29 |
| 45.0 | 292 | 265 | 238 | 207 | 173 | 140 | 111 | 91 | 84 | 83 | 59 | 33 | 30 | 30 | 29 | 28 | 28 |
| 42.5 | 258 | 252 | 239 | 215 | 175 | 130 | 91 | 71 | 74 | 74 | 55 | 34 | 27 | 26 | 25 | 25 | 25 |
| 40.0 | 224 | 238 | 241 | 222 | 177 | 121 | 72 | 51 | 63 | 64 | 52 | 35 | 24 | 21 | 21 | 22 | 22 |
| 37.5 | 196 | 217 | 226 | 211 | 167 | 118 | 61 | 41 | 53 | 47 | 39 | 30 | 20 | 18 | 19 | 19 | 19 |
| 35.0 | 168 | 195 | 210 | 208 | 157 | 108 | 50 | 31 | 44 | 29 | 25 | 25 | 15 | 15 | 17 | 16 | 15 |
| 32.5 | 140 | 162 | 174 | 166 | 132 | 86 | 45 | 27 | 33 | 25 | 20 | 18 | 12 | 12 | 13 | 14 | 14 |
| 30.0 | 111 | 128 | 137 | 131 | 107 | 72 | 40 | 22 | 23 | 21 | 15 | 10 | 9 | 10 | 10 | 11 | 12 |

LONGITUDE: 150W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | | | 530 | 335 | 183 | 104 | 83 | 94 | 110 | 110 | 98 | 88 | 64 | 50 | | | |
| 57.5 | | | 462 | 307 | 185 | 121 | 103 | 109 | 118 | 112 | 96 | 77 | 62 | 49 | | | |
| 55.0 | | | 344 | 276 | 187 | 139 | 126 | 125 | 126 | 114 | 94 | 74 | 60 | 49 | | | |
| 52.5 | | | 306 | 262 | 179 | 134 | 118 | 117 | 115 | 103 | 83 | 63 | 48 | 37 | | | |
| 50.0 | | | 330 | 245 | 171 | 129 | 113 | 109 | 105 | 91 | 72 | 52 | 37 | 25 | | | |
| 47.5 | | | 320 | 235 | 165 | 123 | 103 | 96 | 92 | 85 | 73 | 59 | 43 | 27 | | | |
| 45.0 | | | 302 | 225 | 160 | 117 | 93 | 82 | 79 | 78 | 76 | 66 | 50 | 29 | | | |
| 42.5 | | | 249 | 183 | 128 | 91 | 72 | 63 | 61 | 59 | 56 | 49 | 38 | 25 | | | |
| 40.0 | | | 195 | 141 | 95 | 66 | 51 | 44 | 42 | 40 | 37 | 33 | 27 | 20 | | | |
| 37.5 | | | 184 | 126 | 78 | 49 | 36 | 33 | 33 | 31 | 28 | 23 | 19 | 15 | | | |
| 35.0 | | | 173 | 111 | 61 | 32 | 22 | 21 | 23 | 22 | 18 | 14 | 11 | 9 | | | |
| 32.5 | | | 148 | 96 | 53 | 28 | 20 | 17 | 18 | 17 | 15 | 12 | 10 | 9 | | | |
| 30.0 | | | 124 | 48 | 45 | 24 | 15 | 13 | 13 | 13 | 11 | 9 | 9 | 8 | | | |

LONGITUDE: MEAN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 792 | 628 | 561 | 334 | 202 | 124 | 99 | 119 | 154 | 135 | 121 | 103 | 87 | 159 | 359 | 332 | 229 |
| 57.5 | 635 | 528 | 442 | 315 | 208 | 161 | 114 | 124 | 147 | 126 | 110 | 101 | 98 | 117 | 222 | 202 | 144 |
| 55.0 | 479 | 428 | 384 | 295 | 214 | 158 | 129 | 129 | 140 | 113 | 108 | 98 | 89 | 76 | 86 | 71 | 58 |
| 52.5 | 393 | 374 | 355 | 276 | 194 | 132 | 101 | 118 | 140 | 106 | 84 | 79 | 68 | 52 | 54 | 46 | 44 |
| 50.0 | 307 | 320 | 325 | 257 | 175 | 106 | 72 | 92 | 141 | 97 | 68 | 66 | 47 | 29 | 21 | 21 | 30 |
| 47.5 | 300 | 293 | 297 | 236 | 170 | 117 | 87 | 89 | 111 | 89 | 67 | 55 | 43 | 29 | 25 | 25 | 29 |
| 45.0 | 292 | 265 | 270 | 216 | 166 | 128 | 102 | 86 | 81 | 88 | 66 | 49 | 40 | 29 | 29 | 28 | 28 |
| 42.5 | 258 | 252 | 244 | 199 | 151 | 118 | 81 | 67 | 67 | 66 | 55 | 41 | 37 | 25 | 25 | 25 | 25 |
| 40.0 | 224 | 238 | 218 | 181 | 136 | 93 | 61 | 47 | 56 | 52 | 44 | 34 | 25 | 20 | 21 | 22 | 22 |
| 37.5 | 196 | 217 | 205 | 168 | 122 | 79 | 48 | 37 | 43 | 39 | 33 | 26 | 19 | 16 | 19 | 19 | 19 |
| 35.0 | 168 | 195 | 191 | 155 | 109 | 66 | 36 | 26 | 33 | 25 | 21 | 19 | 13 | 12 | 17 | 16 | 15 |
| 32.5 | 140 | 162 | 161 | 131 | 92 | 57 | 31 | 22 | 25 | 21 | 17 | 15 | 11 | 10 | 13 | 14 | 14 |
| 30.0 | 111 | 128 | 130 | 105 | 76 | 48 | 27 | 17 | 18 | 17 | 13 | 9 | 9 | 9 | 10 | 11 | 12 |

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TABLE 3. Seasonal values of $K_{yz}$ ($10^1 \ m^2 sec^{-1}$).

SEASON:WINTER HORIZONTAL DIFFUSION COEFFICIENTS (K-YZ) IN 10 METERS SQUARED PER SECOND

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LONGITUDE: 80W | | | | | | | | | | | | | | | | | |
| 60.0 KM | -188 | -165 | -135 | -53 | 273 | 307 | 12 | 261 | 398 | -308 | -426 | 624 | 281 | -211 | -31 | 3 | -32 |
| 57.5 | -225 | -188 | -135 | -49 | 268 | 391 | 18 | 518 | 427 | -313 | -432 | 406 | 189 | -154 | -24 | 4 | -28 |
| 55.0 | -261 | -211 | -134 | -46 | 262 | 475 | 605 | 775 | 456 | -320 | -338 | 188 | 97 | -116 | -17 | 4 | -23 |
| 52.5 | -218 | -181 | -112 | -35 | 193 | 344 | 443 | 563 | 388 | -211 | -238 | 131 | 74 | -85 | -10 | 3 | -17 |
| 50.0 | -174 | -152 | -89 | -25 | 123 | 214 | 288 | 351 | 320 | -101 | -137 | 74 | 52 | -54 | -4 | 2 | -12 |
| 47.5 | -168 | -145 | -76 | -15 | 43 | 56 | 107 | 260 | 225 | -83 | -71 | 48 | 37 | -31 | -3 | 0 | -6 |
| 45.0 | -162 | -139 | -63 | -5 | -36 | -101 | -66 | 169 | 130 | -65 | -4 | 23 | 22 | -8 | -2 | 0 | 0 |
| 42.5 | -239 | -193 | -79 | -4 | -69 | -160 | -112 | 117 | 106 | -55 | -22 | 26 | 16 | -6 | -1 | 0 | 0 |
| 40.0 | -317 | -246 | -96 | -2 | -101 | -219 | -159 | 65 | 82 | -45 | -41 | 29 | 11 | -4 | 0 | 0 | 0 |
| 37.5 | -259 | -215 | -86 | 0 | -103 | -203 | -127 | 56 | 51 | -38 | -23 | 18 | 6 | -5 | 0 | 0 | 0 |
| 35.0 | -201 | -184 | -76 | 0 | -104 | -187 | -95 | 42 | 20 | -30 | -4 | 7 | 0 | -5 | 0 | 0 | 0 |
| 32.5 | -129 | -125 | -54 | 0 | -75 | -133 | -59 | 49 | 3 | -40 | -3 | 2 | 2 | 0 | 0 | 0 | 0 |
| 30.0 | -56 | -66 | -31 | 0 | -46 | -78 | -22 | 56 | -13 | -50 | -1 | -2 | 4 | 3 | 0 | 0 | 0 |
| LONGITUDE: 150W | | | | | | | | | | | | | | | | | |
| 60.0 KM | | | 18 | -1 | 103 | 372 | 621 | 687 | 365 | 130 | 50 | 66 | 84 | 67 | | | |
| 57.5 | | | 24 | 0 | 101 | 403 | 683 | 726 | 346 | 90 | 4 | 19 | 46 | 39 | | | |
| 55.0 | | | 30 | 2 | 98 | 433 | 745 | 764 | 326 | 49 | -41 | -26 | 8 | 10 | | | |
| 52.5 | | | 48 | 10 | 32 | 283 | 551 | 593 | 264 | 55 | -17 | -23 | -12 | -10 | | | |
| 50.0 | | | 66 | 19 | -34 | 134 | 358 | 422 | 202 | 60 | 5 | -20 | -32 | -32 | | | |
| 47.5 | | | 77 | 20 | -65 | -7 | 100 | 151 | 84 | 37 | 17 | 3 | -8 | -12 | | | |
| 45.0 | | | 88 | 22 | -97 | -149 | -157 | -118 | -33 | 14 | 30 | 26 | 15 | 6 | | | |
| 42.5 | | | 83 | 19 | -84 | -129 | -136 | -108 | -39 | 1 | 17 | 18 | 11 | 5 | | | |
| 40.0 | | | 78 | 17 | -71 | -108 | -115 | -98 | -46 | -11 | 5 | 10 | 7 | 4 | | | |
| 37.5 | | | 44 | 10 | -50 | -83 | -91 | -77 | -34 | -6 | 4 | 5 | 3 | 1 | | | |
| 35.0 | | | 11 | 3 | -28 | -57 | -66 | -56 | -22 | -2 | 3 | 1 | -1 | -1 | | | |
| 32.5 | | | 0 | 0 | -13 | -30 | -35 | -33 | -17 | -6 | -1 | 0 | 0 | 0 | | | |
| 30.0 | | | -12 | -1 | 1 | -2 | -4 | -10 | -13 | -11 | -6 | -1 | 1 | 1 | | | |
| LONGITUDE: MEAN | | | | | | | | | | | | | | | | | |
| 60.0 KM | -188 | -165 | -58 | -27 | 186 | 340 | 317 | 474 | 381 | -88 | -238 | 345 | 182 | -71 | -31 | 3 | -32 |
| 57.5 | -225 | -186 | -55 | -24 | 184 | 397 | 351 | 622 | 386 | -112 | -214 | 213 | 117 | -62 | -24 | 4 | -28 |
| 55.0 | -261 | -211 | -52 | -21 | 180 | 454 | 675 | 770 | 391 | -135 | -189 | 88 | 52 | -52 | -17 | 4 | -23 |
| 52.5 | -218 | -181 | [illegible] | -12 | 112 | 314 | 497 | 578 | 326 | -78 | -128 | 54 | 31 | -48 | -10 | 3 | -17 |
| 50.0 | -174 | -152 | -11 | -3 | 44 | 174 | 319 | 386 | 261 | -20 | -66 | 27 | 9 | -43 | -4 | 2 | -12 |
| 47.5 | -168 | -145 | 0 | 2 | -11 | 24 | 103 | 206 | 154 | -22 | -26 | 26 | 14 | -21 | -3 | 0 | -6 |
| 45.0 | -162 | -139 | 12 | 8 | -67 | -125 | -111 | 25 | 48 | -25 | 12 | 24 | 18 | 0 | -2 | 0 | 0 |
| 42.5 | -239 | -193 | 1 | 7 | -76 | -144 | -124 | 4 | 33 | -27 | -2 | 22 | 14 | 0 | -1 | 0 | 0 |
| 40.0 | -317 | -246 | -9 | 7 | -86 | -164 | -137 | -16 | 18 | -28 | -17 | 20 | 9 | 0 | 0 | 0 | 0 |
| 37.5 | -259 | -215 | -21 | 4 | -76 | -143 | -109 | -11 | 8 | -22 | -9 | 12 | 4 | -1 | 0 | 0 | 0 |
| 35.0 | -201 | -184 | -32 | 2 | -66 | -122 | -81 | -7 | -1 | -16 | 0 | 4 | 0 | -3 | 0 | 0 | 0 |
| 32.5 | -129 | -125 | -27 | 0 | -44 | -81 | -47 | 7 | -7 | -23 | -2 | 1 | 1 | 0 | 0 | 0 | 0 |
| 30.0 | -56 | -66 | -22 | 0 | -22 | -48 | -13 | 22 | -13 | -30 | -3 | -1 | 2 | 2 | 0 | 0 | 0 |

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TABLE 3. Seasonal values of $K_{yz}$ ($10^1\ m^2 sec^{-1}$).

SEASON:SPRING HORIZONTAL DIFFUSION COEFFICIENTS (K-YZ) IN 10 METERS SQUARED PER SECOND

LONGITUDE: 80W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 67 | -1 | -200 | -479 | -375 | -162 | -124 | -98 | -135 | 243 | 382 | -1172 | -1000 | 1249 | 350 | -103 | -230 |
| 57.5 | -97 | -136 | -244 | -379 | -277 | -137 | -131 | -137 | -151 | 213 | 283 | -755 | -723 | 776 | 198 | -70 | -144 |
| 55.0 | -262 | -272 | -280 | -278 | -178 | -112 | -139 | -176 | -167 | 182 | 185 | -337 | -438 | 303 | 43 | -38 | -57 |
| 52.5 | -139 | -153 | -186 | -237 | -186 | -120 | -125 | -137 | -163 | 134 | 194 | -253 | -271 | 198 | 38 | -30 | -46 |
| 50.0 | -16 | -35 | -93 | -196 | -193 | -120 | -118 | -99 | -118 | 85 | 202 | -170 | -103 | 93 | 18 | -23 | -34 |
| 47.5 | 8 | 0 | -35 | -184 | -113 | -79 | -72 | -70 | -116 | 42 | 179 | -125 | -64 | 79 | 18 | -15 | -25 |
| 45.0 | 32 | 36 | 22 | -12 | -33 | -38 | -34 | -41 | -114 | 0 | 157 | -80 | -26 | 64 | 18 | -7 | -16 |
| 42.5 | -12 | -10 | -1 | 11 | 10 | 0 | -11 | -35 | -90 | 5 | 129 | -61 | -13 | 49 | 15 | -4 | -11 |
| 40.0 | -57 | -57 | -26 | 34 | 54 | 31 | 11 | -28 | -66 | 11 | 101 | -42 | -1 | 33 | 12 | -1 | -6 |
| 37.5 | -98 | -105 | -68 | 17 | 61 | 40 | 21 | -15 | -44 | 22 | 73 | -36 | -14 | 36 | 11 | -2 | -6 |
| 35.0 | -139 | -154 | -110 | 0 | 67 | 50 | 31 | -2 | -22 | 33 | 65 | -29 | -28 | 38 | 11 | -3 | -6 |
| 32.5 | -114 | -155 | -143 | -36 | 51 | 44 | 26 | 0 | -6 | 28 | 34 | -23 | -22 | 16 | 5 | 0 | -1 |
| 30.0 | -89 | -155 | -169 | -72 | 35 | 37 | 21 | 2 | 0 | 24 | 23 | -18 | -16 | -5 | 0 | 3 | 3 |

LONGITUDE: 150W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | | | 220 | 134 | -35 | -123 | -247 | -302 | -415 | -345 | -260 | -148 | -64 | -40 | | | |
| 57.5 | | | 114 | 51 | -84 | -150 | -235 | -294 | -273 | -221 | -154 | -89 | -41 | -25 | | | |
| 55.0 | | | 9 | -31 | -133 | -176 | -223 | -207 | -130 | -77 | -47 | -30 | -17 | -10 | | | |
| 52.5 | | | 11 | -17 | -88 | -105 | -137 | -139 | -101 | -66 | -39 | -14 | 3 | 0 | | | |
| 50.0 | | | 14 | -3 | -27 | -34 | -52 | -72 | -71 | -56 | -31 | 1 | 26 | 26 | | | |
| 47.5 | | | 62 | 36 | -6 | -23 | -42 | -63 | -66 | -51 | -23 | 12 | 34 | 34 | | | |
| 45.0 | | | 109 | 77 | 14 | -13 | -33 | -55 | -60 | -47 | -15 | 24 | 44 | 41 | | | |
| 42.5 | | | 103 | 76 | 23 | -2 | -18 | -34 | -42 | -36 | -9 | 32 | 52 | 42 | | | |
| 40.0 | | | 96 | 79 | 32 | 8 | -2 | -13 | -23 | -25 | -3 | 40 | 60 | 43 | | | |
| 37.5 | | | 52 | 45 | 25 | 12 | 8 | 1 | -8 | -12 | -3 | 19 | 30 | 22 | | | |
| 35.0 | | | 8 | 12 | 17 | 17 | 20 | 16 | 7 | 0 | -2 | -1 | 0 | 0 | | | |
| 32.5 | | | -5 | -1 | 8 | 11 | 14 | 14 | 9 | 5 | 1 | 0 | -2 | -2 | | | |
| 30.0 | | | -19 | -14 | -1 | 4 | 9 | 12 | 11 | 10 | 6 | 0 | -5 | -5 | | | |

LONGITUDE: MEAN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 67 | -1 | 5 | -172 | -205 | -163 | -105 | -240 | -275 | -61 | 60 | -660 | -536 | 604 | 350 | -103 | -230 |
| 57.5 | -97 | -136 | -64 | -163 | -180 | -143 | -103 | -215 | -212 | -6 | 64 | -422 | -302 | 375 | 198 | -70 | -144 |
| 55.0 | -262 | -272 | -135 | -155 | -156 | -144 | -101 | -191 | -148 | 52 | 68 | -184 | -228 | 146 | 43 | -36 | -57 |
| 52.5 | -139 | -153 | -87 | -127 | -133 | -112 | -131 | -138 | -122 | 33 | 77 | -134 | -133 | 103 | 38 | -30 | -46 |
| 50.0 | -16 | -35 | -39 | -99 | -110 | -81 | -81 | -85 | -95 | 16 | 85 | -84 | -39 | 60 | 18 | -23 | -34 |
| 47.5 | 8 | 0 | 13 | -33 | -80 | -51 | -57 | -66 | -91 | -6 | 70 | -56 | -15 | 56 | 18 | -15 | -25 |
| 45.0 | 32 | 36 | 66 | 32 | -9 | -21 | -34 | -48 | -87 | -23 | 70 | -28 | 9 | 53 | 13 | -7 | -16 |
| 42.5 | -12 | -10 | 50 | 44 | 17 | 0 | -14 | -34 | -60 | -15 | 59 | -14 | 19 | 45 | 15 | -4 | -11 |
| 40.0 | -57 | -57 | 34 | 56 | 43 | 19 | 4 | -21 | -45 | -6 | 68 | 0 | 29 | 38 | 12 | -1 | -6 |
| 37.5 | -98 | -105 | -8 | 31 | 43 | 26 | 15 | -7 | -26 | 4 | 35 | -6 | 7 | 29 | 11 | -2 | -6 |
| 35.0 | -139 | -154 | -50 | 6 | 42 | 33 | 25 | 7 | -7 | 16 | 21 | -15 | -13 | 19 | 11 | -3 | -6 |
| 32.5 | -114 | -155 | -72 | -18 | 29 | 27 | 20 | 7 | 1 | 17 | 18 | -12 | -12 | 7 | 5 | 0 | -1 |
| 30.0 | -89 | -155 | -94 | -43 | 16 | 21 | 15 | 7 | 10 | 17 | 15 | -9 | -11 | -5 | 0 | 3 | 3 |

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TABLE 3. Seasonal values of $K_{yz}$ ($10^1\ m^2 sec^{-1}$).

SEASON:SUMMER HORIZONTAL DIFFUSION COEFFICIENTS (K-YZ) IN 10 METERS SQUARED PER SECOND

LONGITUDE: 80W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 0 | 0 | -7 | -20 | -34 | -45 | -14 | 84 | 80 | 14 | 8 | -66 | 224 | 312 | 27 | 17 | 137 |
| 57.5 | 0 | 0 | -6 | -16 | -24 | -28 | -9 | 51 | 46 | 24 | 43 | -46 | 122 | 189 | 17 | 10 | 88 |
| 55.0 | 0 | 0 | -5 | -12 | -14 | -11 | -4 | 18 | 11 | 33 | 78 | -27 | 21 | 67 | 8 | 4 | 39 |
| 52.5 | 0 | 0 | -3 | -7 | -8 | -6 | -2 | 8 | 0 | 25 | 62 | -31 | 10 | 63 | 8 | 2 | 29 |
| 50.0 | 0 | 0 | -2 | -3 | -2 | -2 | -1 | 0 | -13 | 18 | 47 | -36 | 0 | 59 | 8 | 1 | 19 |
| 47.5 | 0 | 0 | -1 | -1 | -1 | -1 | 0 | 0 | -13 | 12 | 47 | -31 | -1 | 44 | 6 | 1 | 15 |
| 45.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -12 | 5 | 47 | -25 | -4 | 28 | 4 | 0 | 11 |
| 42.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -7 | 3 | 27 | -14 | -1 | 17 | 2 | 0 | 6 |
| 40.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | 1 | 7 | -2 | 1 | 5 | 1 | 0 | 2 |
| 37.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 2 | 5 | -2 | 0 | 3 | 0 | 0 | 0 |
| 35.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | -1 | -1 | 1 | 0 | 0 | -1 |
| 32.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | -1 | -1 | 1 | 0 | 0 | 0 |
| 30.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | -1 | -1 | 1 | 0 | 0 | 0 |

LONGITUDE: 150W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | | | 0 | 0 | -1 | -4 | -5 | -2 | 6 | 15 | 15 | 9 | | 1 | | | |
| 57.5 | | | 0 | -1 | -4 | -8 | -9 | -4 | 4 | 13 | 14 | 11 | 5 | 3 | | | |
| 55.0 | | | 0 | -2 | -7 | -12 | -12 | -7 | 1 | 10 | 14 | 13 | 7 | 4 | | | |
| 52.5 | | | 0 | -2 | -4 | -7 | -7 | -4 | 0 | 4 | 9 | 13 | 11 | 7 | | | |
| 50.0 | | | 0 | -1 | -1 | -2 | -2 | -2 | -2 | -1 | 3 | 13 | 16 | 11 | | | |
| 47.5 | | | 0 | -1 | -1 | -1 | -1 | -1 | -1 | 0 | 3 | 12 | 15 | 11 | | | |
| 45.0 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 11 | 15 | 12 | | | |
| 42.5 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 9 | 7 | | | |
| 40.0 | | | 0 | 0 | 0 | 0 | -1 | -1 | -1 | 0 | 1 | 4 | 4 | 2 | | | |
| 37.5 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | | | |
| 35.0 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| 32.5 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| 30.0 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |

LONGITUDE: MEAN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 0 | 0 | -3 | -10 | -18 | -24 | -9 | 41 | 43 | 15 | 11 | -28 | 114 | 156 | 27 | 17 | 137 |
| 57.5 | 0 | 0 | -3 | -8 | -14 | -18 | -9 | 23 | 25 | 18 | 29 | -17 | 64 | 96 | 17 | 10 | 88 |
| 55.0 | 0 | 0 | -3 | -7 | -10 | -11 | -8 | 5 | 6 | 22 | 46 | -6 | 14 | 36 | 8 | 4 | 39 |
| 52.5 | 0 | 0 | -2 | -4 | -6 | -6 | -5 | 2 | 0 | 15 | 36 | -9 | 11 | 35 | 8 | 2 | 29 |
| 50.0 | 0 | 0 | -1 | -2 | -2 | -2 | -1 | -1 | -7 | 8 | 25 | -11 | 8 | 35 | 8 | 1 | 19 |
| 47.5 | 0 | 0 | 0 | -1 | -1 | -1 | 0 | 0 | -7 | 5 | 25 | -9 | 6 | [illegible] | 6 | 1 | 15 |
| 45.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -6 | 2 | 25 | -6 | 5 | 20 | 4 | 0 | 11 |
| 42.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -4 | 1 | 14 | -3 | 4 | 12 | 2 | 0 | 6 |
| 40.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 4 | 0 | 3 | 4 | 1 | 0 | 2 |
| 37.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 0 |
| 35.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | -1 |
| 32.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | -1 | 0 | 0 | 0 | 0 | 0 |

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TABLE 3. Seasonal values of $K_{yz}$ ($10^1$ $m^2 sec^{-1}$).

SEASON:AUTUMN HORIZONTAL DIFFUSION COEFFICIENTS (K-YZ) IN 10 METERS SQUARED PER SECOND

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LONGITUDE: 80W | | | | | | | | | | | | | | | | | |
| 60.0 KM | 10 | 296 | 517 | 490 | 314 | 223 | 142 | 138 | 100 | -1 | 45 | -154 | -233 | 595 | 186 | -351 | -641 |
| 57.5 | 8 | 245 | 463 | 459 | 289 | 199 | 126 | 117 | 77 | 0 | 64 | -119 | -167 | 356 | 100 | -207 | -377 |
| 55.0 | 5 | 194 | 409 | 428 | 265 | 176 | 107 | 95 | 49 | 0 | 39 | -84 | -100 | 115 | 13 | -64 | -116 |
| 52.5 | 4 | 149 | 305 | 315 | 178 | 104 | 59 | 61 | 37 | 0 | 22 | -53 | -53 | 70 | 9 | -36 | -71 |
| 50.0 | 2 | 86 | 200 | 202 | 92 | 33 | 10 | 28 | 24 | 0 | 4 | -21 | -7 | 25 | 4 | -8 | -29 |
| 47.5 | 1 | 61 | 132 | 115 | 33 | -1 | 2 | 23 | 14 | 0 | 5 | -15 | -1 | 31 | 9 | -10 | -32 |
| 45.0 | 1 | 36 | 63 | 28 | -26 | -36 | -4 | 18 | 5 | 0 | 6 | -9 | 4 | 38 | 13 | -12 | -35 |
| 42.5 | 0 | 30 | 51 | 10 | -43 | -46 | -9 | 11 | 2 | 0 | 6 | -2 | 5 | 24 | 9 | -6 | -20 |
| 40.0 | 0 | 23 | 38 | -6 | -40 | -56 | -13 | 5 | 0 | 0 | 5 | 3 | 6 | 10 | 5 | 0 | -4 |
| 37.5 | 0 | 19 | 33 | -4 | -51 | -48 | -12 | 2 | -1 | 0 | 4 | 1 | 4 | 11 | 5 | 0 | -6 |
| 35.0 | 0 | 16 | 28 | -2 | -41 | -41 | -12 | 0 | -2 | 0 | 4 | -1 | 2 | 11 | 5 | -2 | -8 |
| 32.5 | 0 | 10 | 18 | -1 | -28 | -38 | -11 | -2 | -2 | 0 | 2 | 0 | 1 | 8 | 3 | -1 | -6 |
| 30.0 | 0 | 4 | 8 | 0 | -14 | -20 | -11 | -4 | -2 | 0 | 1 | 0 | 1 | 4 | 1 | 0 | -3 |
| LONGITUDE: 150W | | | | | | | | | | | | | | | | | |
| 60.0 KM | | | -117 | -68 | 51 | 102 | 82 | 61 | 29 | 0 | -15 | -26 | -36 | -40 | | | |
| 57.5 | | | -88 | -44 | 54 | 109 | 89 | 59 | 25 | 0 | -10 | -19 | -28 | -32 | | | |
| 55.0 | | | -44 | -20 | 57 | 116 | 95 | 56 | 20 | 0 | -5 | -11 | -20 | -25 | | | |
| 52.5 | | | -37 | -20 | 40 | 86 | 71 | 42 | 14 | 0 | -2 | -6 | -12 | -15 | | | |
| 50.0 | | | -30 | -28 | 22 | 56 | 46 | 26 | 7 | 0 | 0 | -1 | -5 | -6 | | | |
| 47.5 | | | -26 | -22 | 4 | 24 | 21 | 12 | 2 | 0 | 1 | 1 | -1 | -2 | | | |
| 45.0 | | | -22 | -24 | -14 | -6 | -7 | -2 | -2 | 0 | 3 | 4 | 2 | 1 | | | |
| 42.5 | | | -13 | -15 | -13 | -10 | -6 | -3 | -2 | 0 | 2 | 5 | 7 | 8 | | | |
| 40.0 | | | -3 | -7 | -12 | -15 | -9 | -5 | -1 | 0 | 2 | 7 | 13 | 14 | | | |
| 37.5 | | | 3 | 0 | -8 | -12 | -7 | -4 | -1 | 0 | 1 | 5 | 8 | 10 | | | |
| 35.0 | | | 10 | 6 | -5 | -9 | -5 | -3 | -1 | 0 | 0 | 2 | 4 | 5 | | | |
| 32.5 | | | 10 | 7 | -2 | -6 | -4 | -2 | -1 | 0 | 0 | 1 | 2 | 3 | | | |
| 30.0 | | | 10 | 8 | 0 | -3 | -2 | -1 | -1 | 0 | 0 | 1 | 1 | 1 | | | |
| LONGITUDE: MEAN | | | | | | | | | | | | | | | | | |
| 60.0 KM | 10 | 296 | 200 | 210 | 182 | 162 | 112 | 90 | 67 | 0 | 36 | -90 | -135 | 278 | 186 | -351 | -641 |
| 57.5 | 8 | 245 | 191 | 207 | 172 | 154 | 106 | 88 | 51 | 0 | 26 | -69 | -97 | 161 | 100 | -207 | -377 |
| 55.0 | 5 | 194 | 182 | 204 | 161 | 146 | 101 | 76 | 35 | 0 | 17 | -48 | -60 | 45 | 13 | -64 | -116 |
| 52.5 | 4 | 140 | 133 | 147 | 109 | 95 | 65 | 52 | 25 | 0 | 9 | -29 | -33 | 27 | 8 | -36 | -71 |
| 50.0 | 2 | 86 | 85 | 91 | 57 | 44 | 28 | 27 | 16 | 0 | 2 | -11 | -6 | 9 | 4 | -8 | -29 |
| 47.5 | 1 | 61 | 52 | 46 | 18 | 11 | 12 | 17 | 8 | 0 | 3 | -7 | -1 | 14 | 9 | -10 | -32 |
| 45.0 | 1 | 36 | 20 | 1 | -20 | -21 | -3 | 8 | 1 | 0 | 5 | -2 | 3 | 19 | 13 | -12 | -35 |
| 42.5 | 0 | 30 | 18 | -2 | -28 | -28 | -7 | 4 | 0 | 0 | 4 | 1 | 6 | 16 | 9 | -6 | -20 |
| 40.0 | 0 | 23 | 17 | -7 | -36 | -35 | -11 | 0 | 0 | 0 | 3 | 5 | 9 | 12 | 5 | 0 | -4 |
| 37.5 | 0 | 19 | 18 | -2 | -29 | -30 | -10 | -1 | -1 | 0 | 3 | 3 | 6 | 10 | 5 | 0 | -6 |
| 35.0 | 0 | 16 | 19 | 1 | -23 | -25 | -8 | -2 | -1 | 0 | 2 | 0 | 3 | 8 | 5 | -2 | -8 |
| 32.5 | 0 | 10 | 14 | 2 | -15 | -18 | -7 | -2 | -1 | 0 | 1 | 0 | 2 | 5 | 3 | -1 | -6 |
| 30.0 | 0 | 4 | 9 | 3 | -7 | -11 | -6 | -3 | -1 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | -3 |

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TABLE 4. Seasonal values of $K_{zz}$ ($10^3 cm^2 sec^{-1}$).

SEASON: WINTER          VERTICAL DIFFUSION COEFFICIENTS (K-ZZ) IN CM SQUARED PER SECOND TIMES 10³

LONGITUDE: 80W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 1050 | 1080 | 1000 | 1150 | 1200 | 1300 | 1350 | 1250 | 1150 | 1100 | 1050 | 1200 | 1600 | 2000 | 2100 | 2300 | 2450 |
| 57.5 | 800 | 760 | 770 | 875 | 975 | 1115 | 1185 | 1125 | 1025 | 950 | 900 | 975 | 1200 | 1490 | 1575 | 1750 | 1875 |
| 55.0 | 550 | 520 | 540 | 600 | 750 | 930 | 1020 | 1000 | 900 | 800 | 750 | 750 | 800 | 980 | 1050 | 1200 | 1300 |
| 52.5 | 450 | 415 | 420 | 500 | 600 | 715 | 775 | 750 | 655 | 585 | 585 | 605 | 615 | 710 | 755 | 850 | 950 |
| 50.0 | 350 | 310 | 300 | 400 | 450 | 500 | 530 | 500 | 410 | 370 | 420 | 460 | 430 | 440 | 460 | 500 | 600 |
| 47.5 | 310 | 280 | 275 | 330 | 345 | 375 | 390 | 355 | 280 | 270 | 315 | 350 | 345 | 355 | 375 | 390 | 425 |
| 45.0 | 270 | 250 | 250 | 260 | 240 | 250 | 250 | 210 | 150 | 170 | 210 | 240 | 260 | 270 | 290 | 280 | 250 |
| 42.5 | 210 | 190 | 180 | 180 | 165 | 160 | 150 | 125 | 96 | 100 | 140 | 175 | 195 | 195 | 195 | 185 | 165 |
| 40.0 | 150 | 130 | 110 | 100 | 90 | 70 | 50 | 40 | 30 | 20 | 70 | 110 | 130 | 120 | 100 | 90 | 80 |
| 37.5 | 110 | 96 | 80 | 71 | 61 | 49 | 36 | 28 | 23 | 26 | 47 | 70 | 81 | 75 | 65 | 60 | 57 |
| 35.0 | 70 | 62 | 50 | 41 | 31 | 28 | 22 | 16 | 15 | 18 | 23 | 30 | 31 | 29 | 30 | 30 | 33 |
| 32.5 | 51 | 45 | 37 | 31 | 24 | 22 | 18 | 14 | 14 | 18 | 20 | 21 | 21 | 19 | 20 | 22 | 26 |
| 30.0 | 32 | 28 | 23 | 20 | 17 | 15 | 13 | 12 | 13 | 17 | 16 | 12 | 11 | 8 | 10 | 14 | 18 |

LONGITUDE: 150W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 | | | 2100 | 2000 | 2000 | 1800 | 1600 | 1500 | 1150 | 1100 | 1050 | 1050 | 1150 | 1250 | | | |
| 57.5 | | | 1800 | 1750 | 1850 | 1550 | 1375 | 1275 | 1075 | 1000 | 925 | 950 | 1050 | 1125 | | | |
| 55.0 | | | 1500 | 1500 | 1700 | 1300 | 1150 | 1050 | 1000 | 900 | 800 | 850 | 950 | 1000 | | | |
| 52.5 | | | 1000 | 1025 | 1150 | 975 | 075 | 795 | 760 | 700 | 625 | 625 | 710 | 765 | | | |
| 50.0 | | | 500 | 550 | 600 | 650 | 600 | 540 | 520 | 500 | 450 | 400 | 470 | 530 | | | |
| 47.5 | | | 350 | 425 | 475 | 520 | 455 | 410 | 370 | 350 | 315 | 305 | 345 | 390 | | | |
| 45.0 | | | 200 | 300 | 350 | 390 | 310 | 260 | 220 | 200 | 180 | 210 | 220 | 250 | | | |
| 42.5 | | | 115 | 230 | 285 | 290 | 210 | 175 | 135 | 130 | 130 | 150 | 155 | 165 | | | |
| 40.0 | | | 30 | 160 | 220 | 190 | 110 | 70 | 50 | 60 | 80 | 90 | 90 | 80 | | | |
| 37.5 | | | 18 | 95 | 146 | 118 | 68 | 45 | 33 | 38 | 54 | 63 | 81 | [illegible] | | | |
| 35.0 | | | 6 | 30 | 71 | 45 | 25 | 20 | 10 | 15 | 28 | 36 | 71 | [illegible] | | | |
| 32.5 | | | 14 | 25 | 44 | 30 | 19 | 19 | 16 | 18 | 22 | 26 | 50 | [illegible] | | | |
| 30.0 | | | 21 | 19 | 17 | 14 | 12 | 18 | 21 | 20 | 15 | 16 | 28 | [illegible] | | | |

MEAN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 | 1050 | 1000 | 1419 | 1575 | 1600 | 1550 | 1475 | 1375 | 1150 | 1100 | 1050 | 1125 | 1375 | 1681 | 2100 | 2300 | 2450 |
| 57.5 | 800 | 760 | 1161 | 1313 | 1413 | 1333 | 1280 | 1200 | 1050 | 975 | 913 | 963 | 1125 | 1329 | 1575 | 1750 | 1875 |
| 55.0 | 550 | 520 | 903 | 1050 | 1225 | 1115 | 1085 | 1025 | 950 | 850 | 775 | 800 | 875 | 976 | 1050 | 1200 | 1300 |
| 52.5 | 450 | 415 | 650 | 763 | 875 | 845 | 825 | 773 | 708 | 643 | 605 | 615 | 663 | 726 | 755 | 850 | 950 |
| 50.0 | 350 | 310 | 396 | 475 | 525 | 575 | 565 | 520 | 465 | 435 | 435 | 430 | 450 | 470 | 460 | 500 | 600 |
| 47.5 | 310 | 280 | 321 | 378 | 410 | 448 | 423 | 383 | 325 | 310 | 315 | 328 | 345 | 367 | 375 | 390 | 425 |
| 45.0 | 270 | 250 | 245 | 280 | 295 | 320 | 280 | 245 | 185 | 185 | 195 | 225 | 240 | 263 | 290 | 280 | 250 |
| 42.5 | 210 | 190 | 173 | 205 | 225 | 225 | 180 | 150 | 113 | 115 | 135 | 163 | 175 | 183 | 195 | 185 | 165 |
| 40.0 | 150 | 130 | 100 | 130 | 155 | 130 | 80 | 55 | 40 | 45 | 75 | 100 | 110 | 103 | 100 | 90 | 80 |
| 37.5 | 110 | 96 | 69 | 83 | 104 | 84 | 52 | 37 | 27 | 31 | 51 | 67 | 81 | 76 | 65 | 60 | 57 |
| 35.0 | 70 | 62 | 39 | 36 | 51 | 37 | 24 | 18 | 13 | 17 | 26 | 33 | 51 | 49 | 30 | 30 | 33 |
| 32.5 | 51 | 45 | 31 | 26 | 34 | 26 | 19 | 17 | 15 | 19 | 21 | 24 | 36 | 34 | 20 | 22 | 26 |
| 30.0 | 32 | 28 | 23 | 20 | 17 | 15 | 13 | 15 | 17 | 15 | 16 | 14 | 20 | 19 | 10 | 14 | 18 |

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TABLE 4. Seasonal values of $K_{zz}$ ($10^3 cm^2 sec^{-1}$).

SEASON:SPRING VERTICAL DIFFUSION COEFFICIENTS (K-ZZ) IN CM SQUARED PER SECOND TIMES 10³

LONGITUDE: 80W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 N | 650 | 600 | 600 | 550 | 530 | 550 | 700 | 850 | 1000 | 1100 | 1000 | 900 | 750 | 600 | 700 | 900 | 1050 |
| 57.5 | 550 | 485 | 450 | 405 | 405 | 450 | 575 | 700 | 850 | 950 | 875 | 750 | 625 | 510 | 585 | 750 | 950 |
| 55.0 | 450 | 370 | 300 | 260 | 280 | 350 | 450 | 550 | 700 | 800 | 750 | 600 | 500 | 420 | 470 | 600 | 950 |
| 52.5 | 380 | 325 | 285 | 255 | 270 | 315 | 370 | 435 | 500 | 650 | 635 | 485 | 425 | 410 | 450 | 540 | 685 |
| 50.0 | 310 | 280 | 270 | 250 | 260 | 280 | 290 | 320 | 420 | 500 | 460 | 370 | 350 | 400 | 410 | 440 | 520 |
| 47.5 | 285 | 255 | 230 | 210 | 210 | 225 | 240 | 265 | 340 | 390 | 370 | 305 | 305 | 345 | 365 | 385 | 410 |
| 45.0 | 260 | 230 | 190 | 175 | 160 | 170 | 190 | 210 | 260 | 280 | 280 | 240 | 260 | 290 | 300 | 290 | 300 |
| 42.5 | 200 | 180 | 160 | 145 | 140 | 145 | 150 | 160 | 180 | 185 | 200 | 185 | 185 | 160 | 165 | 185 | 205 |
| 40.0 | 140 | 130 | 130 | 120 | 120 | 120 | 110 | 110 | 100 | 90 | 120 | 130 | 110 | 70 | 30 | 80 | 110 |
| 37.5 | 91 | 87 | 88 | 83 | 87 | 90 | 83 | 76 | 65 | 61 | 88 | 96 | 70 | 25 | 25 | 51 | 70 |
| 35.0 | 41 | 43 | 45 | 46 | 51 | 60 | 56 | 29 | 30 | 32 | 56 | 62 | 30 | 20 | 20 | 22 | 30 |
| 32.5 | 31 | 30 | 30 | 29 | 34 | 30 | 35 | 26 | 19 | 22 | 39 | 42 | 25 | 20 | 20 | 21 | 28 |
| 30.0 | 20 | 17 | 15 | 12 | 14 | 15 | 13 | 10 | 8 | 12 | 21 | 21 | 20 | 20 | 19 | 20 | 25 |

LONGITUDE: 150W

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 | | | 230 | 240 | 250 | 270 | 290 | 310 | 400 | 530 | 1000 | 1050 | 800 | 600 | | | |
| 57.5 | | | 210 | 230 | 255 | 275 | 310 | 355 | 425 | 565 | 910 | 900 | 675 | 510 | | | |
| 55.0 | | | 190 | 220 | 260 | 280 | 330 | 400 | 450 | 600 | 820 | 750 | 550 | 420 | | | |
| 52.5 | | | 180 | 210 | 240 | 280 | 340 | 400 | 445 | 540 | 660 | 600 | 450 | 360 | | | |
| 50.0 | | | 170 | 200 | 220 | 280 | 350 | 400 | 440 | 460 | 600 | 450 | 350 | 300 | | | |
| 47.5 | | | 160 | 180 | 200 | 240 | 300 | 350 | 375 | 395 | 400 | 360 | 275 | 245 | | | |
| 45.0 | | | 150 | 160 | 180 | 200 | 250 | 300 | 310 | 310 | 300 | 270 | 200 | 190 | | | |
| 42.5 | | | 135 | 135 | 140 | 150 | 180 | 210 | 225 | 225 | 225 | 205 | 170 | 160 | | | |
| 40.0 | | | 120 | 110 | 109 | 100 | 110 | 120 | 140 | 144 | 150 | 140 | 140 | 130 | | | |
| 37.5 | | | 97 | 70 | 55 | 60 | 68 | 75 | 86 | 90 | 98 | 94 | 95 | 91 | | | |
| 35.0 | | | 74 | 30 | 19 | 19 | 26 | 29 | 32 | 40 | 45 | 48 | 50 | 52 | | | |
| 32.5 | | | 56 | 21 | 8 | 12 | 17 | 23 | 29 | 34 | 36 | 37 | 37 | 36 | | | |
| 30.0 | | | 37 | 12 | 6 | 5 | 7 | 16 | 26 | 27 | 27 | 25 | 23 | 20 | | | |

MEAN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 | 650 | 600 | 456 | 395 | 390 | 410 | 495 | 580 | 700 | 815 | 1000 | 975 | 775 | 669 | 700 | 900 | 1050 |
| 57.5 | 550 | 485 | 366 | 318 | 330 | 363 | 443 | 528 | 630 | 758 | 893 | 825 | 650 | 566 | 585 | 740 | 950 |
| 55.0 | 450 | 370 | 275 | 240 | 270 | 315 | 390 | 475 | 575 | 700 | 785 | 675 | 525 | 459 | 470 | 600 | 850 |
| 52.5 | 380 | 325 | 256 | 233 | 255 | 298 | 355 | 418 | 503 | 595 | 633 | 543 | 430 | 415 | 450 | 540 | 685 |
| 50.0 | 310 | 280 | 236 | 225 | 240 | 280 | 320 | 360 | 430 | 490 | 480 | 410 | 350 | 370 | 410 | 440 | 520 |
| 47.5 | 285 | 255 | 210 | 195 | 205 | 233 | 270 | 308 | 358 | 343 | 385 | 333 | 290 | 311 | 365 | 385 | 410 |
| 45.0 | 260 | 230 | 184 | 165 | 174 | 185 | 220 | 255 | 285 | 295 | 290 | 255 | 230 | 253 | 300 | 290 | 300 |
| 42.5 | 200 | 180 | 154 | 140 | 140 | 140 | 165 | 185 | 203 | 205 | 213 | 195 | 178 | 166 | 165 | 185 | 205 |
| 40.0 | 140 | 130 | 124 | 115 | 110 | 110 | 110 | 115 | 120 | 115 | 135 | 135 | 125 | 79 | 30 | 80 | 110 |
| 37.5 | 91 | 87 | 88 | 77 | 71 | 75 | 76 | 75 | 76 | 76 | 93 | 95 | 83 | 56 | 25 | 51 | 70 |
| 35.0 | 41 | 43 | 50 | 38 | 32 | 40 | 41 | 36 | 31 | 16 | 51 | 55 | 40 | 33 | 20 | 22 | 30 |
| 32.5 | 31 | 30 | 35 | 25 | 21 | 25 | 26 | 26 | 24 | 28 | 38 | 40 | 31 | 27 | 20 | 21 | 28 |
| 30.0 | 20 | 17 | 20 | 12 | 10 | 10 | 10 | 13 | 17 | 20 | 24 | 23 | 22 | 20 | 19 | 20 | 25 |

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TABLE 4. Seasonal values of $K_{zz}$ ($10^3 cm^2 sec^{-1}$).

SEASON:SUMMER VERTICAL DIFFUSION COEFFICIENTS (K-ZZ) IN CM SQUARED PER SECOND TIMES $10^3$

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LONGITUDE: 80W | | | | | | | | | | | | | | | | | |
| 60.0 KM | 550 | 480 | 470 | 450 | 450 | 430 | 480 | 550 | 1050 | 1800 | 2100 | 2[illegible] | 2000 | 1450 | 1300 | 2000 | 2150 |
| 57.5 | 485 | 440 | 440 | 440 | 415 | 375 | 390 | 420 | 690 | 1150 | 1575 | 1700 | 1500 | 1000 | 975 | 1550 | 1975 |
| 55.0 | 420 | 400 | 410 | 430 | 380 | 320 | 300 | 240 | 330 | 500 | 1050 | 1150 | 1000 | 550 | 650 | 1100 | 1800 |
| 52.5 | 385 | 365 | 370 | 370 | 335 | 290 | 260 | 260 | 295 | 345 | 735 | 860 | 725 | 420 | 475 | 800 | 1350 |
| 50.0 | 350 | 330 | 330 | 310 | 290 | 260 | 220 | 230 | 260 | 290 | 420 | 570 | 450 | 290 | 300 | 500 | 900 |
| 47.5 | 285 | 295 | 300 | 280 | 265 | 200 | 170 | 180 | 230 | 255 | 340 | 430 | 280 | 190 | 200 | 335 | 625 |
| 45.0 | 220 | 260 | 270 | 250 | 200 | 140 | 120 | 130 | 200 | 220 | 260 | 290 | 110 | 90 | 100 | 170 | 350 |
| 42.5 | 165 | 190 | 195 | 180 | 150 | 110 | 90 | 100 | 150 | 175 | 185 | 185 | 80 | 65 | 75 | 125 | 225 |
| 40.0 | 110 | 120 | 120 | 110 | 100 | 80 | 60 | 70 | 100 | 130 | 110 | 80 | 50 | 40 | 50 | 80 | 100 |
| 37.5 | 71 | 78 | 79 | 75 | 76 | 71 | 60 | 62 | 72 | 86 | 71 | 53 | 36 | 31 | 37 | 56 | 67 |
| 35.0 | 31 | 35 | 38 | 40 | 51 | 62 | 60 | 56 | 43 | 38 | 31 | 26 | 22 | 21 | 24 | 28 | 33 |
| 32.5 | 25 | 28 | 30 | 28 | 33 | 37 | 35 | 31 | 29 | 28 | 26 | 24 | 23 | 23 | 21 | 23 | 23 |
| 30.0 | 19 | 20 | 21 | 16 | 15 | 12 | 10 | 8 | 14 | 16 | 20 | 22 | 23 | 25 | 21 | 17 | 13 |
| LONGITUDE: 150W | | | | | | | | | | | | | | | | | |
| 60.0 | | | 350 | 400 | 500 | 600 | 480 | 360 | 320 | 440 | 560 | 800 | 1000 | 1100 | | | |
| 57.5 | | | 265 | 350 | 440 | 485 | 390 | 310 | 285 | 360 | 445 | 640 | 825 | 1050 | | | |
| 55.0 | | | 180 | 300 | 380 | 370 | 300 | 260 | 250 | 280 | 330 | 480 | 650 | 1000 | | | |
| 52.5 | | | 145 | 250 | 325 | 315 | 250 | 190 | 220 | 260 | 300 | 340 | 515 | 720 | | | |
| 50.0 | | | 110 | 200 | 270 | 260 | 200 | 120 | 190 | 240 | 270 | 300 | 380 | 440 | | | |
| 47.5 | | | 100 | 150 | 230 | 210 | 135 | 75 | 135 | 215 | 240 | 255 | 320 | 370 | | | |
| 45.0 | | | 90 | 100 | 190 | 160 | 70 | 30 | 80 | 190 | 210 | 210 | 260 | 300 | | | |
| 42.5 | | | 80 | 50 | 140 | 115 | 50 | 55 | 105 | 150 | 155 | 150 | 185 | 220 | | | |
| 40.0 | | | 70 | 80 | 90 | 70 | 30 | 80 | 130 | 110 | 100 | 90 | 110 | 140 | | | |
| 37.5 | | | 60 | 70 | 73 | 50 | 28 | 60 | 84 | 70 | 63 | 60 | 79 | 100 | | | |
| 35.0 | | | 50 | 60 | 55 | 30 | 25 | 40 | 38 | 30 | 26 | 29 | 45 | 60 | | | |
| 32.5 | | | 38 | 45 | 43 | 25 | 19 | 29 | 32 | 26 | 23 | 26 | 35 | 44 | | | |
| 30.0 | | | 25 | 29 | 30 | 20 | 12 | 18 | 26 | 21 | 20 | 23 | 25 | 28 | | | |
| MEAN | | | | | | | | | | | | | | | | | |
| 60.0 | 550 | 480 | 431 | 425 | 475 | 515 | 480 | 455 | 685 | 1120 | 1330 | 1525 | 1500 | 1338 | 1300 | 2000 | 2150 |
| 57.5 | 485 | 440 | 385 | 395 | 428 | 430 | 390 | 365 | 488 | 755 | 1010 | 1170 | 1163 | 1047 | 975 | 1550 | 1975 |
| 55.0 | 420 | 400 | 339 | 365 | 380 | 345 | 300 | 275 | 290 | 390 | 690 | 815 | 825 | 756 | 650 | 1100 | 1800 |
| 52.5 | 385 | 365 | 298 | 310 | 330 | 303 | 255 | 225 | 258 | 328 | 518 | 625 | 620 | 559 | 475 | 800 | 1350 |
| 50.0 | 350 | 330 | 256 | 255 | 280 | 260 | 210 | 175 | 225 | 265 | 345 | 435 | 415 | 361 | 300 | 500 | 900 |
| 47.5 | 285 | 295 | 228 | 215 | 238 | 205 | 153 | 128 | 183 | 235 | 290 | 343 | 300 | 265 | 200 | 335 | 625 |
| 45.0 | 220 | 260 | 195 | 175 | 195 | 150 | 95 | 80 | 160 | 205 | 235 | 250 | 185 | 169 | 100 | 170 | 350 |
| 42.5 | 165 | 190 | 150 | 135 | 145 | 113 | 70 | 78 | 128 | 163 | 170 | 168 | 133 | 124 | 75 | 125 | 225 |
| 40.0 | 110 | 120 | 101 | 95 | 95 | 75 | 45 | 75 | 115 | 120 | 105 | 85 | 80 | 78 | 50 | 80 | 100 |
| 37.5 | 71 | 78 | 73 | 73 | 75 | 61 | 44 | 61 | 78 | 77 | 67 | 57 | 57 | 57 | 37 | 56 | 67 |
| 35.0 | 31 | 35 | 43 | 50 | 53 | 46 | 43 | 47 | 41 | 34 | 29 | 28 | 34 | 35 | 24 | 28 | 33 |
| 32.5 | 25 | 28 | 33 | 37 | 38 | 31 | 27 | 30 | 31 | 27 | 25 | 25 | 29 | 30 | 23 | 23 | 23 |
| 30.0 | 19 | 20 | 22 | 21 | 23 | 16 | 11 | 13 | 20 | 20 | 20 | 23 | 24 | 25 | 21 | 17 | 13 |

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TABLE 4. Seasonal values of $K_{zz}$ ($10^3 cm^2 sec^{-1}$).

SEASON: AUTUMN VERTICAL DIFFUSION COEFFICIENTS (K-ZZ) IN CM SQUARED PER SECOND TIMES 10$^3$

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LONGITUDE: 80W | | | | | | | | | | | | | | | | | |
| 60.0 KM | 570 | 590 | 640 | 620 | 580 | 530 | 520 | 600 | 750 | 1000 | 1400 | 2000 | 2200 | 2300 | 2100 | 1800 | 1450 |
| 57.5 | 535 | 540 | 555 | 540 | 510 | 475 | 470 | 515 | 615 | 825 | 1425 | 1725 | 2000 | 2100 | 1900 | 1650 | 1250 |
| 55.0 | 500 | 490 | 470 | 460 | 440 | 420 | 420 | 430 | 480 | 650 | 1050 | 1450 | 1800 | 1900 | 1700 | 1500 | 1050 |
| 52.5 | 410 | 410 | 410 | 430 | 425 | 415 | 420 | 425 | 435 | 525 | 775 | 1150 | 1425 | 1500 | 1350 | 1175 | 825 |
| 50.0 | 320 | 330 | 350 | 400 | 410 | 410 | 420 | 420 | 390 | 400 | 500 | 850 | 1050 | 1100 | 1000 | 850 | 600 |
| 47.5 | 250 | 265 | 295 | 335 | 350 | 360 | 380 | 375 | 330 | 330 | 390 | 590 | 765 | 805 | 750 | 645 | 465 |
| 45.0 | 180 | 200 | 240 | 270 | 290 | 310 | 340 | 330 | 270 | 260 | 280 | 330 | 480 | 510 | 500 | 440 | 330 |
| 42.5 | 150 | 160 | 175 | 190 | 205 | 225 | 260 | 250 | 200 | 190 | 210 | 255 | 350 | 375 | 350 | 300 | 230 |
| 40.0 | 120 | 120 | 110 | 110 | 120 | 140 | 180 | 170 | 130 | 120 | 140 | 180 | 220 | 240 | 200 | 160 | 130 |
| 37.5 | 105 | 95 | 85 | 81 | 90 | 103 | 120 | 110 | 86 | 78 | 98 | 130 | 153 | 158 | 132 | 107 | 88 |
| 35.0 | 90 | 70 | 60 | 52 | 68 | 65 | 60 | 50 | 41 | 35 | 55 | 80 | 85 | 75 | 64 | 53 | 45 |
| 32.5 | 58 | 47 | 40 | 34 | 38 | 40 | 38 | 34 | 30 | 28 | 40 | 55 | 58 | 54 | 46 | 38 | 31 |
| 30.0 | 25 | 24 | 20 | 16 | 15 | 15 | 16 | 17 | 19 | 21 | 24 | 29 | 30 | 32 | 28 | 22 | 17 |
| LONGITUDE: 150W | | | | | | | | | | | | | | | | | |
| 60.0 | | | 1500 | 1600 | 1500 | 1300 | 1150 | 1050 | 1100 | 1150 | 1150 | 1050 | 400 | 300 | | | |
| 57.5 | | | 1350 | 1350 | 1250 | 1125 | 975 | 800 | 775 | 825 | 450 | 875 | 385 | 315 | | | |
| 55.0 | | | 1200 | 1100 | 1000 | 950 | 800 | 550 | 450 | 500 | 750 | 700 | 370 | 330 | | | |
| 52.5 | | | 925 | 825 | 750 | 725 | 600 | 450 | 410 | 450 | 605 | 600 | 395 | 335 | | | |
| 50.0 | | | 650 | 550 | 500 | 500 | 400 | 350 | 370 | 400 | 460 | 500 | 420 | 340 | | | |
| 47.5 | | | 385 | 320 | 290 | 300 | 280 | 275 | 300 | 335 | 380 | 410 | 375 | 320 | | | |
| 45.0 | | | 120 | 90 | 80 | 100 | 160 | 200 | 230 | 270 | 300 | 320 | 330 | 300 | | | |
| 42.5 | | | 95 | 65 | 50 | 65 | 120 | 150 | 170 | 190 | 210 | 230 | 240 | 235 | | | |
| 40.0 | | | 70 | 40 | 20 | 30 | 80 | 100 | 110 | 110 | 120 | 140 | 150 | 170 | | | |
| 37.5 | | | 61 | 34 | 22 | 28 | 56 | 73 | 86 | 81 | 82 | 90 | 98 | 115 | | | |
| 35.0 | | | 52 | 27 | 23 | 26 | 31 | 45 | 62 | 52 | 43 | 40 | 45 | 59 | | | |
| 32.5 | | | 44 | 25 | 22 | 21 | 25 | 34 | 44 | 39 | 32 | 29 | 32 | 40 | | | |
| 30.0 | | | 35 | 22 | 20 | 16 | 18 | 23 | 26 | 25 | 20 | 17 | 19 | 21 | | | |
| MEAN | | | | | | | | | | | | | | | | | |
| 60.0 | 570 | 590 | 960 | 1110 | 1040 | 915 | 835 | 825 | 925 | 1075 | 1475 | 1525 | 1300 | 1500 | 2100 | 1800 | 1450 |
| 57.5 | 535 | 540 | 848 | 945 | 880 | 800 | 723 | 658 | 695 | 825 | 1138 | 1300 | 1193 | 1377 | 1900 | 1650 | 1250 |
| 55.0 | 500 | 490 | 735 | 780 | 720 | 685 | 610 | 490 | 465 | 575 | 900 | 1075 | 1085 | 1254 | 1700 | 1500 | 1050 |
| 52.5 | 410 | 410 | 594 | 628 | 588 | 570 | 510 | 438 | 423 | 488 | 690 | 875 | 910 | 1024 | 1350 | 1175 | 825 |
| 50.0 | 320 | 330 | 451 | 475 | 455 | 455 | 410 | 385 | 380 | 400 | 480 | 675 | 735 | 794 | 1000 | 850 | 600 |
| 47.5 | 250 | 265 | 318 | 328 | 320 | 330 | 330 | 325 | 315 | 333 | 385 | 500 | 570 | 612 | 750 | 645 | 465 |
| 45.0 | 180 | 200 | 185 | 180 | 185 | 205 | 250 | 265 | 250 | 265 | 290 | 325 | 405 | 429 | 500 | 440 | 330 |
| 42.5 | 150 | 160 | 140 | 128 | 128 | 145 | 190 | 209 | 185 | 190 | 210 | 243 | 295 | 314 | 350 | 300 | 230 |
| 40.0 | 120 | 120 | 94 | 75 | 70 | 85 | 130 | 135 | 120 | 115 | 130 | 160 | 185 | 199 | 200 | 160 | 130 |
| 37.5 | 105 | 95 | 75 | 58 | 56 | 66 | 88 | 92 | 86 | 80 | 90 | 110 | 126 | 133 | 132 | 107 | 88 |
| 35.0 | 90 | 70 | 56 | 40 | 42 | 46 | 46 | 48 | 52 | 46 | 49 | 60 | 65 | 66 | 64 | 53 | 45 |
| 32.5 | 58 | 47 | 40 | 30 | 30 | 31 | 32 | 34 | 37 | 36 | 35 | 42 | 45 | 46 | 46 | 38 | 31 |
| 30.0 | 25 | 24 | 25 | 19 | 18 | 16 | 17 | 20 | 23 | 23 | 22 | 23 | 25 | 27 | 28 | 22 | 17 |

TABLE 5. Seasonal mean temperatures ($^{o}K$).

THIS PAGE IS BEST QUALITY PRACTICABLE FROM COPY FURNISHED TO DDC

SEASON:WINTER MEAN T

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 258 | 258 | 259 | 260 | 260 | 259 | 257 | 255 | 256 | 256 | 258 | 259 | 260 | 260 | 261 | 261 | 260 |
| 57.5 | 257 | 258 | 259 | 260 | 261 | 261 | 260 | 258 | 258 | 258 | 261 | 264 | 265 | 265 | 266 | 266 | 265 |
| 55.0 | 256 | 257 | 258 | 260 | 261 | 262 | 262 | 261 | 260 | 260 | 264 | 268 | 270 | 270 | 270 | 270 | 270 |
| 52.5 | 254 | 254 | 254 | 257 | 260 | 262 | 262 | 263 | 263 | 264 | 267 | 270 | 271 | 272 | 272 | 271 | 271 |
| 50.0 | 251 | 250 | 250 | 253 | 258 | 261 | 262 | 264 | 266 | 266 | 269 | 271 | 272 | 273 | 273 | 272 | 272 |
| 47.5 | 248 | 246 | 246 | 249 | 254 | 259 | 261 | 263 | 266 | 269 | 270 | 271 | 271 | 271 | 271 | 271 | 271 |
| 45.0 | 244 | 242 | 241 | 244 | 250 | 256 | 260 | 262 | 265 | 270 | 270 | 270 | 269 | 269 | 269 | 270 | 270 |
| 42.5 | 238 | 237 | 236 | 239 | 245 | 253 | 256 | 257 | 260 | 263 | 263 | 264 | 263 | 263 | 263 | 264 | 264 |
| 40.0 | 232 | 231 | 230 | 233 | 240 | 250 | 252 | 252 | 254 | 255 | 256 | 257 | 257 | 257 | 257 | 257 | 257 |
| 37.5 | 228 | 227 | 227 | 229 | 235 | 245 | 247 | 247 | 247 | 248 | 248 | 249 | 249 | 249 | 249 | 249 | 249 |
| 35.0 | 223 | 223 | 223 | 225 | 229 | 239 | 241 | 241 | 240 | 240 | 240 | 241 | 241 | 240 | 240 | 240 | 241 |
| 32.5 | 220 | 220 | 221 | 222 | 226 | 233 | 234 | 234 | 235 | 235 | 235 | 235 | 235 | 235 | 235 | 235 | 236 |
| 30.0 | 216 | 217 | 218 | 219 | 222 | 226 | 226 | 227 | 229 | 230 | 230 | 229 | 229 | 229 | 229 | 230 | 231 |

SEASON:SPRING

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 268 | 266 | 265 | 264 | 262 | 260 | 259 | 257 | 257 | 258 | 257 | 256 | 257 | 257 | 258 | 258 | 259 |
| 57.5 | 270 | 269 | 268 | 267 | 266 | 264 | 263 | 261 | 261 | 262 | 261 | 260 | 261 | 261 | 262 | 262 | 263 |
| 55.0 | 271 | 271 | 270 | 270 | 270 | 268 | 266 | 265 | 265 | 265 | 265 | 264 | 265 | 265 | 265 | 266 | 266 |
| 52.5 | 271 | 272 | 271 | 271 | 271 | 270 | 269 | 268 | 268 | 268 | 268 | 268 | 269 | 268 | 268 | 269 | 268 |
| 50.0 | 271 | 272 | 272 | 272 | 271 | 271 | 271 | 271 | 271 | 270 | 271 | 271 | 272 | 271 | 271 | 271 | 270 |
| 47.5 | 268 | 268 | 269 | 269 | 270 | 270 | 270 | 271 | 270 | 269 | 270 | 270 | 271 | 271 | 271 | 271 | 271 |
| 45.0 | 264 | 264 | 265 | 266 | 268 | 269 | 269 | 270 | 269 | 268 | 268 | 269 | 270 | 270 | 271 | 271 | 271 |
| 42.5 | 258 | 258 | 258 | 258 | 260 | 262 | 263 | 264 | 264 | 263 | 263 | 264 | 265 | 265 | 266 | 266 | 266 |
| 40.0 | 251 | 251 | 250 | 250 | 252 | 255 | 256 | 257 | 258 | 258 | 258 | 259 | 260 | 260 | 260 | 260 | 261 |
| 37.5 | 246 | 246 | 245 | 245 | 246 | 249 | 250 | 251 | 252 | 252 | 252 | 252 | 253 | 252 | 252 | 252 | 253 |
| 35.0 | 240 | 240 | 239 | 239 | 240 | 243 | 244 | 245 | 245 | 245 | 245 | 245 | 245 | 244 | 244 | 244 | 244 |
| 32.5 | 236 | 235 | 235 | 234 | 235 | 237 | 237 | 239 | 239 | 239 | 239 | 239 | 239 | 239 | 239 | 239 | 239 |
| 30.0 | 231 | 230 | 230 | 229 | 229 | 230 | 230 | 232 | 232 | 233 | 233 | 233 | 232 | 233 | 233 | 233 | 233 |

SEASON:SUMMER

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 276 | 274 | 271 | 268 | 262 | 259 | 257 | 253 | 253 | 253 | 253 | 254 | 256 | 256 | 256 | 255 | 255 |
| 57.5 | 279 | 277 | 275 | 272 | 267 | 264 | 262 | 258 | 258 | 258 | 257 | 258 | 260 | 260 | 260 | 260 | 260 |
| 55.0 | 281 | 280 | 278 | 275 | 271 | 269 | 266 | 263 | 262 | 262 | 261 | 262 | 264 | 264 | 264 | 264 | 265 |
| 52.5 | 283 | 281 | 279 | 277 | 273 | 271 | 269 | 267 | 266 | 266 | 264 | 264 | 265 | 266 | 266 | 267 | 268 |
| 50.0 | 284 | 232 | 280 | 278 | 275 | 272 | 271 | 271 | 270 | 269 | 267 | 266 | 266 | 267 | 268 | 269 | 270 |
| 47.5 | 281 | 280 | 278 | 276 | 274 | 272 | 271 | 271 | 269 | 268 | 266 | 265 | 266 | 266 | 267 | 268 | 268 |
| 45.0 | 277 | 277 | 275 | 274 | 273 | 272 | 271 | 270 | 268 | 266 | 264 | 264 | 265 | 265 | 265 | 266 | 266 |
| 42.5 | 271 | 271 | 269 | 267 | 267 | 266 | 265 | 264 | 262 | [illegible] | 260 | 260 | 260 | 260 | 260 | 261 | 261 |
| 40.0 | 265 | 264 | 262 | 260 | 260 | 260 | 259 | 257 | 256 | 256 | 255 | 255 | 254 | 254 | 255 | 256 | 256 |
| 37.5 | 259 | 257 | 256 | 255 | 255 | 254 | 253 | 252 | 251 | 250 | 249 | 249 | 248 | 248 | 248 | 249 | 250 |
| 35.0 | 252 | 250 | 250 | 249 | 249 | 248 | 247 | 246 | 245 | 243 | 243 | 242 | 241 | 241 | 241 | 242 | 243 |
| 32.5 | 246 | 245 | 245 | 244 | 243 | 242 | 240 | 239 | 239 | 237 | 237 | 237 | 236 | 236 | 236 | 236 | 237 |
| 30.0 | 240 | 239 | 239 | 238 | 237 | 235 | 233 | 232 | 232 | 231 | 231 | 231 | 230 | 230 | 230 | 230 | 230 |

SEASON:AUTUMN

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 261 | 261 | 261 | 260 | 260 | 260 | 259 | 257 | 257 | 256 | 256 | 256 | 256 | 257 | 257 | 257 | 256 |
| 57.5 | 261 | 262 | 262 | 261 | 261 | 262 | 261 | 260 | 260 | 260 | 261 | 261 | 261 | 261 | 261 | 261 | 261 |
| 55.0 | 261 | 262 | 262 | 262 | 262 | 263 | 263 | 263 | 263 | 264 | 265 | 265 | 265 | 265 | 265 | 265 | 265 |
| 52.5 | 259 | 260 | 261 | 261 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 268 | 268 | 268 | 269 | 269 |
| 50.0 | 256 | 257 | 259 | 260 | 260 | 261 | 263 | 265 | 267 | 268 | 269 | 270 | 271 | 271 | 271 | 272 | 272 |
| 47.5 | 251 | 253 | 255 | 256 | 257 | 259 | 262 | 264 | 266 | 267 | 268 | 269 | 270 | 271 | 271 | 271 | 272 |
| 45.0 | 245 | 248 | 250 | 252 | 254 | 257 | 260 | 263 | 264 | 265 | 266 | 268 | 269 | 270 | 270 | 270 | 271 |
| 42.5 | 238 | 241 | 243 | 246 | 248 | 251 | 254 | 256 | 257 | 259 | 260 | 262 | 263 | 264 | 265 | 265 | 266 |
| 40.0 | 231 | 233 | 236 | 239 | 241 | 244 | 247 | 249 | 250 | 252 | 254 | 256 | 257 | 256 | 259 | 259 | 260 |
| 37.5 | 227 | 229 | 231 | 234 | 236 | 239 | 242 | 244 | 245 | 246 | 247 | 249 | 250 | 251 | 252 | 252 | 253 |
| 35.0 | 222 | 224 | 226 | 224 | 230 | 233 | 236 | 238 | 239 | 240 | 240 | 241 | 242 | 243 | 244 | 245 | 246 |
| 32.5 | 219 | 221 | 223 | 225 | 227 | 229 | 232 | 234 | 235 | 235 | 236 | 236 | 237 | 238 | 238 | 238 | 239 |
| 30.0 | 216 | 218 | 220 | 221 | 223 | 225 | 228 | 229 | 230 | 230 | 231 | 231 | 232 | 232 | 231 | 231 | 232 |

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TABLE 6. Variance of temperature ($^{o}K^{2}$).

SEASON:WINTER VAR T

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 72 | 74 | 76 | 73 | 70 | 54 | 35 | 27 | 31 | 33 | 26 | 17 | 14 | 14 | 13 | 14 | 15 |
| 57.5 | 68 | 74 | 74 | 73 | 68 | 52 | 33 | 26 | 29 | 30 | 24 | 17 | 14 | 13 | 13 | 14 | 15 |
| 55.0 | 64 | 73 | 72 | 72 | 66 | 50 | 30 | 25 | 26 | 26 | 22 | 16 | 14 | 12 | 12 | 13 | 15 |
| 52.5 | 68 | 73 | 74 | 73 | 66 | 51 | 31 | 25 | 25 | 24 | 20 | 16 | 14 | 12 | 12 | 13 | 15 |
| 50.0 | 72 | 73 | 75 | 73 | 66 | 52 | 31 | 25 | 24 | 21 | 18 | 15 | 14 | 12 | 12 | 13 | 14 |
| 47.5 | 71 | 74 | 78 | 78 | 71 | 59 | 41 | 33 | 20 | 25 | 19 | 15 | 13 | 13 | 13 | 13 | 1 |
| 45.0 | 76 | 75 | 80 | 83 | 76 | 65 | 50 | 40 | 32 | 28 | 20 | 15 | 12 | 13 | 13 | 12 | 1 |
| 42.5 | 64 | 71 | 79 | 82 | 67 | 58 | 48 | 42 | 35 | 29 | 19 | 15 | 12 | 13 | 13 | 13 | 13 |
| 40.0 | 58 | 66 | 78 | 81 | 58 | 50 | 45 | 43 | 37 | 30 | 18 | 14 | 11 | 12 | 12 | 13 | 14 |
| 37.5 | 49 | 57 | 66 | 66 | 48 | 40 | 36 | 34 | 31 | 25 | 17 | 13 | 11 | 12 | 11 | 12 | 12 |
| 35.0 | 40 | 46 | 54 | 50 | 38 | 29 | 27 | 24 | 24 | 20 | 15 | 12 | 11 | 11 | 10 | 10 | 10 |
| 32.5 | 37 | 41 | 42 | 39 | 31 | 25 | 22 | 20 | 19 | 16 | 13 | 11 | 10 | 9 | 8 | 9 | 9 |
| 30.0 | 34 | 33 | 30 | 28 | 23 | 20 | 17 | 15 | 14 | 11 | 10 | 9 | 8 | 6 | 6 | 7 | 8 |

SEASON:SPRING

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 18 | 16 | 15 | 17 | 17 | 14 | 13 | 15 | 16 | 17 | 13 | 11 | 12 | 12 | 13 | 14 | 14 |
| 57.5 | 20 | 17 | 15 | 16 | 16 | 14 | 13 | 14 | 16 | 16 | 13 | 10 | 12 | 12 | 13 | 14 | 13 |
| 55.0 | 21 | 17 | 14 | 15 | 14 | 13 | 12 | 12 | 15 | 15 | 12 | 9 | 11 | 12 | 12 | 13 | 12 |
| 52.5 | 22 | 19 | 15 | 15 | 14 | 13 | 13 | 13 | 14 | 14 | 12 | 9 | 11 | 12 | 13 | 13 | 12 |
| 50.0 | 22 | 20 | 16 | 14 | 13 | 13 | 13 | 13 | 12 | 12 | 11 | 9 | 10 | 12 | 13 | 12 | 11 |
| 47.5 | 24 | 20 | 17 | 15 | 14 | 14 | 13 | 13 | 12 | 12 | 11 | 9 | 10 | 13 | 14 | 13 | 11 |
| 45.0 | 26 | 20 | 17 | 16 | 14 | 14 | 13 | 13 | 12 | 12 | 11 | 9 | 9 | 13 | 15 | 14 | 11 |
| 42.5 | 28 | 20 | 18 | 16 | 15 | 14 | 13 | 13 | 13 | 13 | 11 | 9 | 9 | 12 | 15 | 15 | 14 |
| 40.0 | 30 | 20 | 18 | 16 | 15 | 13 | 13 | 12 | 14 | 14 | 10 | 9 | 9 | 11 | 15 | 16 | 16 |
| 37.5 | 30 | 20 | 17 | 15 | 15 | 13 | 13 | 12 | 13 | 12 | 10 | 9 | 9 | 11 | 13 | 14 | 14 |
| 35.0 | 30 | 19 | 15 | 14 | 14 | 13 | 12 | 11 | 11 | 10 | 9 | 8 | 9 | 10 | 11 | 11 | 12 |
| 32.5 | 29 | 17 | 14 | 13 | 13 | 12 | 11 | 10 | 9 | 9 | 8 | 7 | 8 | 8 | 9 | 9 | 10 |
| 30.0 | 27 | 14 | 13 | 12 | 11 | 10 | 9 | 9 | 7 | 7 | 6 | 6 | 6 | 5 | 6 | 7 | 8 |

SEASON:SUMMER

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 11 | 9 | 8 | 8 | 8 | 9 | 13 | 20 | 22 | 23 | 22 | 22 | 21 | 19 | 17 | 15 | 15 |
| 57.5 | 13 | 9 | 8 | 8 | 8 | 9 | 12 | 17 | 21 | 23 | 22 | 19 | 18 | 16 | 15 | 16 | 14 |
| 55.0 | 9 | 6 | 7 | 7 | 7 | 8 | 10 | 13 | 19 | 22 | 21 | 16 | 14 | 12 | 12 | 12 | 13 |
| 52.5 | 10 | 9 | 8 | 7 | 7 | 8 | 10 | 13 | 17 | 21 | 17 | 16 | 13 | 12 | 12 | 12 | 12 |
| 50.0 | 11 | 10 | 9 | 7 | 7 | 8 | 10 | 12 | 14 | 19 | 13 | 11 | 11 | 12 | 12 | 11 | 11 |
| 47.5 | 14 | 12 | 10 | 8 | 7 | 8 | 10 | 12 | 14 | 17 | 13 | 13 | 13 | 12 | 12 | 11 | 10 |
| 45.0 | 17 | 13 | 11 | 9 | 7 | 7 | 9 | 11 | 13 | 15 | 12 | 15 | 15 | 11 | 11 | 10 | 9 |
| 42.5 | 17 | 14 | 11 | 9 | 7 | 7 | 8 | 10 | 12 | 15 | 12 | 14 | 14 | 11 | 10 | 9 | 9 |
| 40.0 | 16 | 15 | 11 | 8 | 7 | 7 | 7 | 8 | 11 | 14 | 12 | 13 | 13 | 10 | 9 | 8 | 8 |
| 37.5 | 15 | 15 | 12 | [illegible] | 7 | 7 | 7 | 7 | 9 | 11 | 10 | 11 | 10 | 9 | 8 | 8 | 8 |
| 35.0 | 13 | 14 | 12 | 8 | 7 | 6 | 6 | 6 | 7 | 8 | 8 | 8 | 7 | 7 | 7 | 8 | 8 |
| 32.5 | 12 | 12 | 9 | 6 | 6 | 5 | 5 | 6 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 7 | 7 |
| 30.0 | 11 | 10 | 6 | 4 | 4 | 4 | 4 | 5 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 6 | 6 |

SEASON:AUTUMN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 33 | 34 | 38 | 41 | 30 | 26 | 22 | 19 | 19 | 30 | 21 | 18 | 16 | 15 | 15 | 15 | 16 |
| 57.5 | 33 | 34 | 38 | 40 | 38 | 26 | 21 | 19 | 19 | 26 | 19 | 16 | 15 | 14 | 14 | 14 | 13 |
| 55.0 | 32 | 34 | 37 | 39 | 30 | 25 | 20 | 18 | 18 | 22 | 17 | 14 | 13 | 13 | 12 | 12 | 11 |
| 52.5 | 34 | 35 | 37 | 36 | 30 | 25 | 20 | 18 | 18 | 19 | 16 | 13 | 12 | 13 | 12 | 12 | 10 |
| 50.0 | 35 | 35 | 36 | 32 | 30 | 24 | 20 | 17 | 17 | 16 | 14 | 11 | 11 | 12 | 12 | 11 | 9 |
| 47.5 | 39 | 35 | 39 | 32 | 29 | 24 | 20 | 18 | 17 | 16 | 14 | 12 | 12 | 12 | 12 | 11 | 10 |
| 45.0 | 35 | 35 | 33 | 31 | 27 | 23 | 19 | 18 | 16 | 16 | 14 | 13 | 13 | 12 | 12 | 11 | 10 |
| 42.5 | 30 | 31 | 29 | 25 | 22 | 19 | 17 | 16 | 15 | 17 | 15 | 13 | 13 | 14 | 14 | 13 | 11 |
| 40.0 | 25 | 26 | 24 | 19 | 17 | 14 | 14 | 13 | 14 | 17 | 18 | 12 | 13 | 16 | 16 | 14 | 11 |
| 37.5 | 20 | 21 | 20 | 17 | 15 | 13 | 12 | 11 | 12 | 15 | 15 | 12 | 12 | 13 | 13 | 12 | 11 |
| 35.0 | 14 | 16 | 16 | 14 | 13 | 11 | 10 | 9 | 10 | 12 | 14 | 11 | 11 | 10 | 10 | 10 | 11 |
| 32.5 | 12 | 14 | 14 | 12 | 11 | 10 | 9 | 8 | 9 | 11 | 12 | 10 | 10 | 9 | 9 | 9 | 10 |
| 30.0 | 10 | 11 | 12 | 10 | 9 | 8 | 7 | 7 | 7 | 10 | 10 | 9 | 8 | 7 | 7 | 8 | 8 |

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TABLE 7. Seasonal mean zonal wind speed ($10^1$ m $sec^{-1}$).

SEASON:WINTER MEAN U

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 150 | 175 | 190 | 430 | 480 | 540 | 600 | 715 | 700 | 580 | 470 | 400 | 300 | 210 | 200 | 160 | 80 |
| 57.5 | 113 | 150 | 190 | 425 | 475 | 535 | 605 | 713 | 653 | 525 | 410 | 325 | 215 | 140 | 103 | 55 | -39 |
| 55.0 | 75 | 125 | 190 | 420 | 470 | 530 | 610 | 710 | 605 | 470 | 350 | 250 | 130 | 70 | 5 | -50 | -160 |
| 52.5 | 73 | 128 | 195 | 410 | 465 | 535 | 605 | 680 | 578 | 435 | 420 | 175 | 30 | -14 | -82 | -134 | -224 |
| 50.0 | 70 | 130 | 200 | 400 | 460 | 540 | 600 | 650 | 550 | 400 | 290 | 100 | -70 | -100 | -170 | -220 | -300 |
| 47.5 | 65 | 140 | 205 | 365 | 433 | 515 | 590 | 628 | 518 | 390 | 250 | 48 | -72 | -124 | -184 | -262 | -354 |
| 45.0 | 60 | 150 | 210 | 330 | 405 | 490 | 580 | 605 | 465 | 380 | 210 | -5 | -75 | -150 | -200 | -305 | -420 |
| 42.5 | 68 | 150 | 215 | 300 | 378 | 445 | 500 | 518 | 428 | 335 | 205 | -12 | -67 | -129 | -199 | -292 | -384 |
| 40.0 | 75 | 150 | 220 | 270 | 350 | 400 | 420 | 430 | 370 | 290 | 200 | -20 | -60 | -110 | -200 | -280 | -350 |
| 37.5 | 88 | 155 | 220 | 265 | 310 | 340 | 370 | 390 | 335 | 260 | 185 | -9 | -44 | -117 | -187 | -249 | -324 |
| 35.0 | 100 | 160 | 220 | 260 | 270 | 280 | 320 | 350 | 300 | 230 | 170 | 0 | -30 | -125 | -175 | -220 | -300 |
| 32.5 | 110 | 165 | 215 | 240 | 245 | 253 | 268 | 275 | 248 | 185 | 130 | 3 | -24 | -82 | -142 | -199 | -257 |
| 30.0 | 120 | 170 | 210 | 220 | 220 | 225 | 215 | 200 | 195 | 140 | 90 | 5 | -20 | -40 | -110 | -180 | -215 |

SEASON:SPRING

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | -50 | -35 | -10 | 10 | 20 | 40 | 45 | 45 | 30 | 30 | 60 | 75 | 120 | 150 | 180 | 250 | 300 |
| 57.5 | -54 | -34 | -12 | 20 | 40 | 58 | 65 | 63 | 45 | 45 | 63 | 83 | 103 | 128 | 160 | 220 | 265 |
| 55.0 | -60 | -35 | -15 | 30 | 60 | 75 | 85 | 80 | 60 | 60 | 65 | 70 | 85 | 105 | 140 | 190 | 230 |
| 52.5 | -64 | -37 | -17 | 25 | 55 | 88 | 103 | 103 | 78 | 70 | 60 | 53 | 58 | 83 | 120 | 160 | 200 |
| 50.0 | -70 | -40 | -20 | 20 | 50 | 100 | 120 | 125 | 95 | 80 | 55 | 35 | 36 | 50 | 100 | 130 | 170 |
| 47.5 | -59 | -34 | -14 | 20 | 55 | 103 | 125 | 138 | 103 | 60 | 35 | 3 | 3 | 35 | 70 | 100 | 133 |
| 45.0 | -50 | -30 | -10 | 20 | 60 | 105 | 130 | 150 | 110 | 80 | 15 | -30 | -25 | 10 | 40 | 70 | 95 |
| 42.5 | -42 | -29 | -14 | 10 | 53 | 103 | 125 | 153 | 125 | 85 | 8 | -64 | -72 | -44 | -14 | 20 | 35 |
| 40.0 | -35 | -30 | -20 | 0 | 45 | 100 | 120 | 155 | 140 | 90 | 0 | -100 | -120 | -100 | -70 | -30 | -25 |
| 37.5 | -27 | -24 | -19 | -2 | 33 | 85 | 113 | 148 | 133 | 90 | 0 | -102 | -124 | -137 | -114 | -89 | -87 |
| 35.0 | -20 | -20 | -20 | -5 | 20 | 70 | 105 | 140 | 125 | 90 | 0 | -105 | -130 | -175 | -160 | -150 | -150 |
| 32.5 | -14 | -14 | -14 | -7 | 8 | 38 | 73 | 105 | 88 | 60 | -9 | -92 | -127 | -162 | -154 | -154 | -159 |
| 30.0 | -10 | -10 | -10 | -10 | -5 | 5 | 40 | 70 | 50 | 30 | -20 | -80 | -125 | -150 | -150 | -160 | -170 |

SEASON:SUMMER

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | -230 | -270 | -310 | -340 | -375 | -405 | -460 | -505 | -500 | -400 | -300 | -190 | -95 | -60 | -30 | 0 | 25 |
| 57.5 | -207 | -239 | -279 | -314 | -347 | -392 | -434 | -467 | -484 | -419 | -349 | -234 | -142 | -84 | -54 | -24 | 3 |
| 55.0 | -185 | -210 | -250 | -290 | -320 | -380 | -410 | -430 | -470 | -440 | -400 | -280 | -190 | -110 | -80 | -50 | -20 |
| 52.5 | -172 | -192 | -224 | -257 | -297 | -342 | -384 | -414 | -444 | -432 | -404 | -314 | -232 | -162 | -124 | -84 | -59 |
| 50.0 | -160 | -175 | -200 | -225 | -275 | -305 | -360 | -400 | -420 | -425 | -410 | -350 | -275 | -215 | -170 | -120 | -100 |
| 47.5 | -144 | -157 | -179 | -202 | -237 | -277 | -329 | -364 | -394 | -412 | -409 | -362 | -292 | -234 | -184 | -139 | -104 |
| 45.0 | -130 | -140 | -160 | -180 | -200 | -250 | -300 | -330 | -370 | -400 | -410 | -375 | -310 | -255 | -200 | -160 | -110 |
| 42.5 | -109 | -119 | -137 | -157 | -177 | -219 | -252 | -289 | -324 | -349 | -364 | -352 | -312 | -262 | -204 | -159 | -104 |
| 40.0 | -90 | -100 | -115 | -135 | -155 | -190 | -205 | -250 | -280 | -300 | -320 | -330 | -315 | -270 | -210 | -160 | -100 |
| 37.5 | -74 | -87 | -104 | -119 | -137 | -167 | -187 | -219 | -242 | -262 | -289 | -309 | -304 | -267 | -209 | -159 | -107 |
| 35.0 | -60 | -75 | -95 | -105 | -120 | -145 | -170 | -190 | -205 | -225 | -260 | -290 | -295 | -255 | -210 | -160 | -105 |
| 32.5 | -57 | -69 | -82 | -92 | -104 | -122 | -142 | -162 | -187 | -207 | -239 | -274 | -274 | -242 | -204 | -159 | -104 |
| 30.0 | -55 | -65 | -70 | -80 | -90 | -100 | -115 | -135 | -170 | -190 | -220 | -260 | -255 | -230 | -200 | -160 | -115 |

SEASON:AUTUMN

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 220 | 250 | 280 | 320 | 350 | 380 | 420 | 500 | 470 | 410 | 350 | 290 | 195 | 180 | 175 | 165 | 145 |
| 57.5 | 215 | 248 | 280 | 323 | 358 | 390 | 448 | 498 | 440 | 393 | 340 | 295 | 193 | 173 | 158 | 140 | 120 |
| 55.0 | 210 | 245 | 280 | 325 | 365 | 400 | 475 | 495 | 410 | 375 | 330 | 300 | 190 | 165 | 140 | 115 | 95 |
| 52.5 | 153 | 185 | 233 | 328 | 358 | 395 | 443 | 450 | 390 | 353 | 315 | 260 | 180 | 158 | 133 | 100 | 83 |
| 50.0 | 95 | 125 | 185 | 330 | 350 | 390 | 410 | 405 | 370 | 330 | 303 | 220 | 170 | 150 | 125 | 100 | 70 |
| 47.5 | 135 | 178 | 230 | 320 | 338 | 360 | 370 | 360 | 330 | 290 | 255 | 263 | 155 | 128 | 108 | 75 | 50 |
| 45.0 | 175 | 230 | 275 | 310 | 325 | 330 | 320 | 315 | 290 | 250 | 210 | 185 | 140 | 105 | 90 | 50 | 30 |
| 42.5 | 165 | 213 | 248 | 275 | 288 | 295 | 290 | 275 | 265 | 210 | 178 | 130 | 75 | 48 | 35 | 13 | 5 |
| 40.0 | 155 | 195 | 220 | 240 | 258 | 260 | 250 | 235 | 200 | 170 | 130 | 75 | 10 | -10 | -20 | -25 | -20 |
| 37.5 | 148 | 178 | 200 | 213 | 218 | 225 | 215 | 203 | 178 | 140 | 90 | 30 | -34 | -54 | -57 | -52 | -39 |
| 35.0 | 140 | 160 | 180 | 185 | 185 | 190 | 180 | 170 | 140 | 110 | 50 | -15 | -80 | -100 | -95 | -80 | -60 |
| 32.5 | 135 | 148 | 160 | 158 | 150 | 145 | 138 | 125 | 95 | 63 | 5 | -59 | -95 | -119 | -117 | -104 | -84 |
| 30.0 | 130 | 135 | 140 | 130 | 115 | 100 | 95 | 80 | 50 | 15 | -40 | -105 | -120 | -140 | -140 | -130 | -110 |

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TABLE 8. Variance of zonal wind speed ($m^2 sec^{-2}$).

SEASON:WINTER VAR U

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 630 | 600 | 560 | 520 | 495 | 340 | 300 | 240 | 310 | 315 | 275 | 250 | 220 | 140 | 170 | 160 | 150 |
| 57.5 | 620 | 555 | 530 | 535 | 563 | 443 | 340 | 310 | 338 | 320 | 273 | 240 | 205 | 175 | 160 | 150 | 140 |
| 55.0 | 610 | 510 | 500 | 550 | 630 | 495 | 380 | 340 | 365 | 375 | 270 | 230 | 190 | 160 | [illegible] | 140 | [illegible] |
| 52.5 | 510 | 445 | 440 | 515 | 615 | 548 | 403 | 345 | 398 | 323 | 265 | 220 | 180 | 155 | 145 | 138 | 133 |
| 50.0 | 410 | 380 | 380 | 430 | 600 | 600 | 425 | 350 | 430 | 320 | 260 | 210 | 170 | 150 | 140 | 135 | 135 |
| 47.5 | 355 | 320 | 333 | 413 | 510 | 550 | 413 | 340 | 413 | 310 | 243 | 195 | 150 | 125 | 118 | 113 | 110 |
| 45.0 | 300 | 275 | 285 | 345 | 420 | 500 | 400 | 330 | 395 | 300 | 225 | 180 | 130 | 100 | 95 | 90 | [illegible] |
| 42.5 | 280 | 258 | 253 | 280 | 328 | 373 | 340 | 305 | 330 | 250 | 183 | 138 | 105 | 88 | 83 | 76 | [illegible] |
| 40.0 | 260 | 240 | 220 | 215 | 235 | 245 | 280 | 280 | 265 | 200 | 140 | 95 | 80 | 75 | 70 | 62 | 55 |
| 37.5 | 245 | 218 | 183 | 183 | 195 | 195 | 228 | 248 | 238 | 178 | 118 | 83 | 65 | 62 | 59 | 54 | 50 |
| 35.0 | 230 | 195 | 145 | 150 | 155 | 165 | 175 | 215 | 210 | 155 | 95 | 70 | 50 | 48 | 48 | 46 | 45 |
| 32.5 | 210 | 178 | 140 | 140 | 143 | 135 | 145 | 160 | 153 | 115 | 73 | 55 | 40 | 38 | 37 | 36 | 35 |
| 30.0 | 190 | 160 | 135 | 130 | 130 | 125 | 115 | 105 | 95 | 75 | 50 | 40 | 30 | 28 | 28 | 25 | 24 |

SEASON:SPRING

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 180 | 175 | 160 | 155 | 155 | 160 | 140 | 125 | 120 | 115 | 120 | 125 | 120 | 125 | 120 | 110 | 105 |
| 57.5 | 160 | 150 | 135 | 130 | 135 | 145 | 130 | 118 | 110 | 105 | 106 | 108 | 110 | 115 | 109 | 100 | 92 |
| 55.0 | 140 | 125 | 110 | 105 | 115 | 130 | 120 | 110 | 100 | 95 | 92 | 95 | 100 | 105 | 98 | 90 | 78 |
| 52.5 | 135 | 113 | 100 | 98 | 110 | 123 | 110 | 100 | 83 | [illegible] | 79 | 80 | 88 | 90 | 84 | 80 | 74 |
| 50.0 | 130 | 100 | 90 | 90 | 105 | 115 | 100 | 90 | 65 | 65 | 65 | 65 | 75 | 75 | 70 | 70 | 70 |
| 47.5 | 120 | 98 | 90 | 88 | 103 | 110 | 95 | 88 | 65 | 65 | 63 | 65 | 68 | 65 | 63 | 64 | 65 |
| 45.0 | 110 | 95 | 90 | 85 | 100 | 105 | 90 | 65 | 65 | 65 | 60 | 65 | 60 | 55 | 55 | 58 | 60 |
| 42.5 | 100 | 83 | 73 | 70 | 80 | 85 | 75 | 73 | 60 | 59 | 55 | 57 | 53 | 50 | 51 | 52 | 53 |
| 40.0 | 105 | 70 | 55 | 55 | 60 | 65 | 60 | 60 | 55 | 53 | 50 | 48 | 45 | 45 | 46 | 46 | 45 |
| 37.5 | 95 | 50 | 48 | 50 | 55 | 58 | 55 | 5 | 50 | 47 | 41 | 40 | 39 | 38 | 38 | 39 | 40 |
| 35.0 | 85 | 45 | 40 | 45 | 50 | 50 | 50 | 50 | 45 | 40 | 32 | 32 | 32 | 30 | 30 | 32 | 34 |
| 32.5 | 68 | 40 | 35 | 40 | 43 | 41 | 41 | 40 | 38 | 32 | 27 | 26 | 26 | 25 | 25 | 26 | 27 |
| 30.0 | 50 | 35 | 30 | 35 | 35 | 32 | 32 | 30 | 26 | 23 | 21 | 20 | 20 | 20 | 20 | 20 | 20 |

SEASON:SUMMER

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 60 | 60 | 55 | 55 | 60 | 70 | 90 | 110 | 160 | 170 | 175 | 180 | 190 | 210 | 215 | 200 | 180 |
| 57.5 | 53 | 50 | 45 | 44 | 58 | 65 | 78 | 90 | 118 | 135 | 130 | 143 | 150 | 168 | 178 | 170 | 150 |
| 55.0 | 45 | 40 | 35 | 40 | 55 | 60 | 85 | 70 | 75 | 100 | 100 | 105 | 110 | 125 | 140 | 140 | 120 |
| 52.5 | 38 | 33 | 29 | 33 | 48 | 58 | 60 | 63 | 65 | 78 | 77 | 80 | 90 | 100 | 113 | 118 | 111 |
| 50.0 | 30 | 26 | 22 | 25 | 40 | 55 | 55 | 55 | 55 | 55 | 53 | 55 | 70 | 75 | 85 | 95 | 102 |
| 47.5 | 28 | 23 | 21 | 23 | 34 | 44 | 47 | 48 | 48 | 49 | 49 | 52 | 61 | 69 | 77 | 85 | 91 |
| 45.0 | 25 | 20 | 20 | 21 | 28 | 32 | 38 | 40 | 40 | 42 | 44 | 48 | 52 | 62 | 68 | 75 | 80 |
| 42.5 | 21 | 16 | 15 | 15 | 21 | 29 | 32 | 31 | 30 | 38 | 40 | 42 | 46 | 56 | 62 | 64 | [illegible] |
| 40.0 | 16 | 12 | 10 | 8 | 14 | 25 | 25 | 22 | 20 | 30 | 35 | 35 | 40 | 50 | 55 | 57 | 62 |
| 37.5 | 14 | 11 | 9 | 8 | 11 | 18 | 18 | 17 | 17 | 26 | 27 | 26 | 30 | 40 | 48 | 50 | 55 |
| 35.0 | 12 | 10 | 8 | [illegible] | 8 | 10 | 10 | 12 | 14 | 18 | 18 | 16 | 20 | 30 | 40 | 43 | 48 |
| 32.5 | 11 | 9 | 7 | 7 | 7 | 9 | 9 | 10 | 12 | 15 | 15 | 14 | 18 | 28 | 34 | 35 | 36 |
| 30.0 | 9 | 7 | 6 | 6 | 6 | 7 | 7 | 7 | 9 | 11 | 11 | 11 | 15 | 25 | 27 | 26 | 23 |

SEASON:AUTUMN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 300 | 330 | 305 | 280 | 260 | 240 | 225 | 195 | 190 | 185 | 170 | 150 | 140 | 130 | 125 | 105 | 95 |
| 57.5 | 325 | 285 | 255 | 243 | 243 | 220 | 198 | 173 | 165 | 163 | 150 | 135 | 125 | 115 | 110 | 90 | 90 |
| 55.0 | 290 | 260 | 205 | 205 | 225 | 200 | 178 | 150 | 140 | 140 | 130 | 120 | 110 | 100 | 95 | 90 | 85 |
| 52.5 | 245 | 205 | 183 | 190 | 183 | 155 | 133 | 120 | 118 | 123 | 110 | 103 | 98 | 90 | 88 | 83 | 80 |
| 50.0 | 200 | 170 | 160 | 175 | 140 | 118 | 95 | 90 | 95 | 105 | 90 | 85 | 85 | 80 | 80 | 75 | 75 |
| 47.5 | 165 | 138 | 128 | 145 | 118 | 100 | 90 | 85 | 83 | 85 | 78 | 73 | 78 | 68 | 78 | 68 | 68 |
| 45.0 | 130 | 105 | 95 | 115 | 95 | 90 | 65 | 60 | 70 | 65 | 65 | 60 | 55 | 55 | 60 | 60 | 60 |
| 42.5 | 105 | 83 | 73 | 93 | 80 | 78 | 78 | 75 | 68 | 60 | 57 | 51 | 49 | 48 | 50 | 51 | 52 |
| 40.0 | 88 | 60 | 50 | 70 | 65 | 65 | 70 | 70 | 65 | 55 | 48 | 42 | 42 | 40 | 40 | 42 | 44 |
| 37.5 | 65 | 50 | 45 | 64 | 60 | 60 | 64 | 64 | 59 | 51 | 43 | 37 | 36 | 34 | 34 | 37 | 41 |
| 35.0 | 50 | 40 | 40 | 57 | 55 | 55 | 57 | 58 | 53 | 47 | 37 | 32 | 30 | 28 | 28 | 32 | 38 |
| 32.5 | 44 | 35 | 35 | 49 | 45 | 45 | 46 | 49 | 44 | 39 | 30 | 25 | 24 | 24 | 25 | 28 | 31 |
| 30.0 | 38 | 30 | 30 | 40 | 35 | 35 | 35 | 40 | 35 | 36 | 23 | 18 | 18 | 20 | 22 | 24 | 24 |

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TABLE 9. Seasonal mean meridional wind speed ($10^1$ m sec$^{-1}$) along 80°W.

SEASON:WINTER MEAN V

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | -40 | -30 | -20 | -8 | 5 | 45 | 85 | 125 | 135 | 120 | 90 | 65 | 25 | -5 | -15 | -25 | -35 |
| 57.5 | -74 | -52 | -32 | -18 | -4 | 33 | 90 | 140 | 145 | 120 | 90 | 68 | 39 | 13 | -6 | -19 | -34 |
| 55.0 | -110 | -75 | 45 | -30 | -15 | 20 | 95 | 155 | 155 | 120 | 90 | 70 | 53 | 30 | 1 | -15 | -35 |
| 52.5 | -139 | -107 | -72 | -42 | -27 | [illegible] | 98 | 158 | 155 | 115 | 85 | 68 | 52 | 30 | 8 | -7 | -37 |
| 50.0 | -170 | -140 | -100 | -55 | -40 | -3 | 100 | 160 | 155 | 110 | 80 | 65 | 50 | 30 | 15 | 0 | -40 |
| 47.5 | -172 | -149 | -124 | -79 | -47 | -8 | 76 | 155 | 145 | 100 | 68 | 65 | 45 | 30 | 18 | 5 | -24 |
| 45.0 | -175 | -160 | -150 | -105 | -55 | -15 | 52 | 150 | 135 | 90 | 55 | 45 | 40 | 30 | 20 | 10 | -10 |
| 42.5 | -189 | -174 | -162 | -129 | -74 | -32 | 39 | 108 | 98 | 68 | 43 | 30 | 25 | 23 | 20 | 13 | -2 |
| 40.0 | -235 | -190 | -175 | -155 | -95 | -50 | 25 | 65 | 60 | 45 | 30 | 15 | 10 | 15 | 20 | 15 | 5 |
| 37.5 | -202 | -199 | -189 | -164 | -109 | -52 | 15 | 50 | 48 | 33 | 18 | 2 | 0 | 7 | 12 | 12 | 7 |
| 35.0 | -200 | -210 | -205 | -175 | -125 | -55 | 5 | 35 | 35 | 2 | 5 | -12 | -10 | -2 | 3 | 8 | 8 |
| 32.5 | -179 | -189 | -192 | -169 | -127 | -54 | 3 | 25 | 28 | | 10 | -3 | -2 | 0 | 0 | 3 | 3 |
| 30.0 | -160 | -170 | -180 | -165 | -130 | -55 | 0 | 15 | 20 | | 15 | 5 | 5 | 0 | -3 | -3 | -2 |
| SEASON:SPRING | | | | | | | | | | | | | | | | | |
| 60.0 KM | 30 | 45 | 50 | 60 | 70 | 65 | 65 | 65 | 65 | 70 | 78 | 74 | 45 | 30 | 20 | 15 | 5 |
| 57.5 | 10 | 28 | 35 | 40 | 60 | 63 | 58 | 70 | 68 | 68 | 72 | 72 | 50 | 35 | 25 | 13 | 0 |
| 55.0 | -10 | 10 | 20 | 35 | 50 | 60 | 70 | 75 | 70 | 65 | 65 | 70 | 55 | 40 | 30 | 10 | -5 |
| 52.5 | -19 | -4 | 8 | 20 | 38 | 51 | 61 | 68 | 68 | 63 | 60 | 60 | 50 | 40 | 25 | 8 | -9 |
| 50.0 | -30 | -20 | -5 | 5 | 25 | 42 | 52 | 60 | 65 | 60 | 55 | 50 | 45 | 40 | 20 | 5 | -15 |
| 47.5 | -39 | -29 | -14 | -4 | 10 | 24 | 39 | 51 | 57 | 53 | 48 | 43 | 36 | 30 | 18 | 8 | -4 |
| 45.0 | -50 | -40 | -25 | -15 | -5 | 5 | 25 | 42 | 49 | 45 | 40 | 35 | 30 | 20 | 15 | 10 | 6 |
| 42.5 | -62 | -50 | -37 | -22 | -12 | 0 | 17 | 29 | 32 | 28 | 25 | 22 | 21 | 18 | 15 | 11 | 13 |
| 40.0 | -75 | -62 | -50 | -30 | -20 | -5 | 8 | 15 | 15 | 10 | 10 | 8 | 12 | 15 | 14 | 12 | 15 |
| 37.5 | -77 | -65 | -52 | -32 | -22 | -7 | 4 | 10 | [illegible] | 10 | 11 | 10 | 10 | 12 | 10 | 10 | 13 |
| 35.0 | -80 | -70 | -55 | -35 | -25 | -10 | 0 | 5 | [illegible] | 10 | 12 | 12 | 8 | 8 | 6 | 8 | 10 |
| 32.5 | -72 | -59 | -47 | -32 | -22 | -9 | 0 | 8 | 10 | 11 | 12 | 12 | 9 | 8 | 7 | 7 | 7 |
| 30.0 | -65 | -50 | -40 | 10 | -20 | -10 | 0 | 10 | 10 | 12 | 12 | 12 | 10 | 8 | 8 | 6 | 4 |
| SEASON:SUMMER | | | | | | | | | | | | | | | | | |
| 60.0 KM | 53 | 55 | 50 | 45 | 40 | 35 | 35 | 30 | 35 | 40 | 43 | 50 | 48 | 45 | 38 | 32 | 25 |
| 57.5 | 48 | 52 | 52 | 50 | 46 | 42 | 41 | 38 | 41 | 46 | 52 | 60 | 57 | 63 | 44 | 14 | 8 |
| 55.0 | 42 | 48 | 53 | 55 | 52 | 49 | 47 | 45 | 46 | 52 | 60 | 70 | 65 | 60 | 50 | 5 | -10 |
| 52.5 | 39 | 42 | 47 | 52 | 53 | 52 | 51 | 50 | 51 | 56 | 58 | 62 | 59 | 56 | 50 | 18 | -9 |
| 50.0 | 35 | 35 | 40 | 48 | 53 | 55 | 55 | 55 | 55 | 60 | 55 | 53 | 52 | 51 | 50 | 30 | -10 |
| 47.5 | 39 | 29 | 30 | 34 | 38 | 41 | 45 | 50 | 48 | 50 | 44 | 39 | 38 | 38 | 39 | 30 | 8 |
| 45.0 | 25 | 22 | 20 | 20 | 23 | 26 | 33 | 45 | 40 | 40 | 33 | 25 | 23 | 25 | 28 | 10 | 26 |
| 42.5 | 22 | 20 | 18 | 18 | 19 | 22 | 25 | 29 | 25 | 23 | 19 | 13 | 11 | 15 | 20 | 23 | 22 |
| 40.0 | 18 | 18 | 16 | 15 | 15 | 18 | 15 | 12 | 10 | 6 | 4 | 0 | -1 | 4 | 12 | 16 | 18 |
| 37.5 | 17 | 17 | 17 | 17 | 16 | 16 | 13 | 11 | 9 | 7 | 5 | 3 | 0 | 0 | 4 | 8 | 9 |
| 35.0 | 16 | 16 | 18 | 16 | 16 | 14 | 11 | 9 | 7 | 7 | 6 | 6 | 0 | -4 | -4 | -1 | 0 |
| 32.5 | 13 | 13 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 8 | 8 | 7 | 2 | 0 | -1 | 0 | -1 |
| 30.0 | 10 | 10 | 9 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 9 | 7 | 4 | 2 | [illegible] | -1 | [illegible] |
| SEASON:AUTUMN | | | | | | | | | | | | | | | | | |
| 60.0 KM | -65 | -60 | -60 | -55 | -50 | -15 | 20 | 55 | 60 | 60 | 55 | 53 | 50 | 25 | 15 | 4 | -8 |
| 57.5 | -72 | -64 | -62 | -52 | -39 | -4 | 35 | 68 | 70 | 69 | 63 | 52 | 45 | 28 | 18 | 2 | -13 |
| 55.0 | -80 | -70 | -65 | -50 | -30 | 5 | 50 | 80 | 80 | 78 | 70 | 50 | 40 | 30 | 20 | 0 | -20 |
| 52.5 | -92 | -82 | -69 | -49 | -27 | 13 | 58 | 85 | 85 | 92 | 68 | 46 | 37 | 29 | 14 | 3 | -14 |
| 50.0 | -105 | -95 | -75 | -50 | -25 | 20 | 65 | 90 | [illegible] | 85 | 65 | 47 | 33 | 28 | 15 | 5 | -10 |
| 47.5 | [illegible] | -99 | -82 | -52 | -29 | 10 | 53 | 80 | 85 | 78 | 55 | 35 | 29 | 22 | 15 | 8 | -2 |
| 45.0 | -125 | -105 | -90 | -55 | -35 | 0 | 40 | 70 | 80 | 70 | 45 | 30 | 25 | 17 | 15 | 10 | 5 |
| 42.5 | -124 | -102 | -84 | -57 | -39 | -2 | 30 | 50 | 55 | 45 | 30 | 23 | 18 | 12 | 12 | 9 | 6 |
| 40.0 | -125 | -100 | -80 | -60 | -45 | -5 | 20 | 30 | 30 | 20 | 15 | 15 | 10 | 8 | 8 | 7 | 7 |
| 37.5 | -117 | -94 | -72 | -5 | -44 | -7 | 15 | 25 | 27 | 19 | 14 | 11 | 5 | 4 | 5 | 6 | 7 |
| 35.0 | -110 | -90 | -65 | -55 | -45 | -10 | 10 | 20 | 23 | 17 | 12 | 7 | 0 | 0 | 2 | 4 | 6 |
| 32.5 | -89 | -72 | -54 | -41 | -37 | -9 | 8 | 16 | 19 | 17 | 13 | 7 | 1 | 0 | 3 | 0 | -1 |
| 30.0 | -70 | -55 | -45 | -40 | -30 | -10 | 5 | 12 | 14 | 16 | 14 | 7 | 2 | 0 | -3 | -6 | -9 |

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TABLE 10. Variance of meridional wind speed ($m^2 sec^{-2}$).

SEASON:WINTER VAR V

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 650 | 600 | 475 | 410 | 360 | 290 | 230 | 165 | 260 | 200 | 170 | 160 | 130 | 125 | 115 | 110 | 105 |
| 57.5 | 750 | 640 | 525 | 435 | 388 | 288 | 190 | 165 | 205 | 148 | 165 | 145 | 123 | 115 | 100 | 100 | [illegible] |
| 55.0 | 650 | 600 | 575 | 460 | 415 | 285 | 180 | 165 | 210 | 175 | 160 | 130 | 115 | 105 | 100 | 90 | [illegible] |
| 52.5 | 800 | 680 | 560 | 465 | 428 | 343 | 215 | 188 | 205 | 168 | 143 | 115 | 105 | 93 | 85 | 75 | 56 |
| 50.0 | 750 | 640 | 560 | 430 | 425 | 480 | 250 | 210 | 200 | 160 | 125 | 100 | 95 | 80 | 70 | 60 | 55 |
| 47.5 | 575 | 600 | 500 | 405 | 443 | 455 | 275 | 203 | 175 | 133 | 108 | 88 | 78 | 65 | 58 | 50 | 48 |
| 45.0 | 600 | 535 | 440 | 380 | 460 | 510 | 300 | 195 | 150 | 105 | 90 | 75 | 60 | 50 | 45 | 40 | 40 |
| 42.5 | 515 | 450 | 380 | 345 | 383 | 380 | 238 | 158 | 123 | 88 | 73 | 60 | 48 | 40 | 38 | 38 | 34 |
| 40.0 | 430 | 365 | 320 | 310 | 305 | 250 | 175 | 120 | 95 | 76 | 55 | 45 | 35 | 30 | 30 | 35 | 35 |
| 37.5 | 378 | 323 | 285 | 275 | 253 | 195 | 135 | 98 | 75 | 55 | 44 | 38 | 25 | 25 | 26 | 24 | 31 |
| 35.0 | 325 | 280 | 250 | 240 | 200 | 140 | 95 | 75 | 55 | 40 | 32 | 26 | 22 | 20 | 21 | 22 | 26 |
| 32.5 | 265 | 233 | 205 | 195 | 150 | 110 | 78 | 62 | 44 | 33 | 26 | 21 | 17 | 15 | 16 | 19 | 23 |
| 30.0 | 205 | 185 | 160 | 150 | 100 | 80 | 60 | 40 | 32 | 25 | 20 | 15 | 12 | 10 | 10 | 15 | 20 |

SEASON:SPRING

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 150 | 135 | 130 | 120 | 125 | 130 | 120 | 100 | 105 | 110 | 105 | 100 | 105 | 105 | 100 | 95 | 90 |
| 57.5 | 155 | 138 | 125 | 105 | 105 | 115 | 108 | 88 | 85 | 75 | 75 | 73 | 77 | 80 | 80 | 74 | 69 |
| 55.0 | 160 | 140 | 120 | 90 | 85 | 100 | 95 | 75 | 65 | 50 | 45 | 45 | 48 | 55 | 60 | 52 | 47 |
| 52.5 | 138 | 125 | 110 | 88 | 75 | 83 | 75 | 63 | 57 | 48 | 40 | 49 | 44 | 49 | 51 | 45 | 41 |
| 0.0 | 115 | 110 | 100 | 85 | 65 | 65 | 55 | 50 | 46 | 45 | 35 | 35 | 40 | 43 | 42 | 37 | 35 |
| 47.5 | 115 | 103 | 98 | 79 | 65 | 61 | 53 | 44 | 44 | 43 | 34 | 31 | 33 | 35 | 35 | 32 | 31 |
| 45.0 | 115 | 95 | 85 | 70 | 65 | 57 | 50 | 38 | 40 | 40 | 32 | 27 | 26 | 26 | 27 | 27 | 26 |
| 42.5 | 98 | 83 | 75 | 68 | 63 | 55 | 45 | 37 | 35 | 35 | 29 | 24 | 23 | 23 | 24 | 24 | 23 |
| 40.0 | 80 | 70 | 65 | 65 | 60 | 52 | 40 | 35 | 30 | 30 | 25 | 21 | 20 | 20 | 21 | 21 | 20 |
| 37.5 | 78 | 70 | 64 | 59 | 55 | 39 | 32 | 28 | 25 | 26 | 22 | 18 | 18 | 18 | 18 | 17 | 16 |
| 35.0 | 75 | 70 | 63 | 53 | 50 | 25 | 23 | 20 | 20 | 21 | 18 | 15 | 15 | 15 | 15 | 12 | 12 |
| 32.5 | 70 | 60 | 52 | 42 | 35 | 20 | 19 | 16 | 16 | 17 | 14 | 12 | 13 | 13 | 12 | 11 | 11 |
| 30.0 | 65 | 50 | 40 | 30 | 20 | 15 | 15 | 12 | 12 | 12 | 9 | 9 | 10 | 10 | 9 | 9 | 9 |

SEASON:SUMMER

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 50 | 52 | 55 | 60 | 60 | 65 | 85 | 100 | 110 | 120 | 125 | 130 | 130 | 125 | 125 | 115 | 105 |
| 57.5 | 38 | 39 | 43 | 46 | 48 | 53 | 64 | 74 | 80 | 93 | 100 | 105 | 100 | 110 | 110 | 100 | 83 |
| 55.0 | 25 | 26 | 30 | 32 | 35 | 40 | 43 | 47 | 50 | 65 | 75 | 80 | 85 | 95 | 95 | 85 | 60 |
| 52.5 | 20 | 21 | 25 | 29 | 32 | 35 | 36 | 40 | 44 | 55 | 62 | 65 | 60 | 72 | 70 | 63 | 49 |
| 50.0 | 15 | 16 | 20 | 26 | 28 | 30 | 32 | 32 | 37 | 44 | 48 | 50 | 50 | 48 | 45 | 41 | 38 |
| 47.5 | 14 | 15 | 18 | 22 | 25 | 27 | 28 | 29 | 31 | 38 | 39 | 39 | 40 | 42 | 39 | 37 | 35 |
| 45.0 | 12 | 14 | 16 | 18 | 21 | 24 | 26 | 24 | 25 | 31 | 30 | 28 | 30 | 35 | 32 | 32 | 31 |
| 42.5 | 11 | 12 | 12 | 13 | [illegible] | 17 | 18 | 20 | 22 | 26 | 27 | 26 | 26 | 29 | 28 | 28 | 27 |
| 40.0 | 9 | 9 | 8 | 8 | [illegible] | 10 | 12 | 16 | 18 | 21 | 23 | 23 | 22 | 22 | 23 | 23 | 22 |
| 37.5 | 8 | 8 | 7 | 7 | 8 | 8 | 10 | 12 | 13 | 16 | 19 | 20 | 19 | 19 | 20 | 18 | 19 |
| 35.0 | 7 | 7 | 6 | 6 | [illegible] | 6 | 7 | 8 | 8 | 10 | 14 | 16 | 16 | 16 | 16 | 15 | 15 |
| 32.5 | 7 | 7 | 6 | 6 | 6 | 5 | 6 | 6 | 7 | 9 | 11 | 12 | 13 | 13 | 13 | 12 | 12 |
| 30.0 | 6 | 6 | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 7 | 7 | 7 | 9 | 9 | 9 | 8 | 8 |

SEASON:AUTUMN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 330 | 320 | 305 | 225 | 190 | 150 | 130 | 115 | 115 | 105 | 95 | 80 | 75 | 65 | 65 | 62 | 62 |
| 57.5 | 315 | 300 | 280 | 220 | 185 | 135 | 110 | 98 | 90 | 95 | 88 | 73 | 70 | 63 | 60 | 56 | 54 |
| 55.0 | 306 | 295 | 270 | 230 | 180 | 120 | 90 | 80 | 80 | 85 | 80 | 65 | 65 | 60 | 55 | 50 | 45 |
| 52.5 | 245 | 245 | 233 | 208 | 153 | 108 | 80 | 60 | 60 | 75 | 65 | 53 | 50 | 40 | 43 | 40 | 40 |
| 50.0 | 190 | 195 | 195 | 185 | [illegible] | 95 | 70 | 55 | 55 | 65 | 50 | 40 | 35 | 35 | 30 | 30 | 35 |
| 47.5 | 160 | 165 | 163 | 145 | 105 | 78 | 59 | 50 | 51 | 56 | 44 | 37 | 34 | 35 | 30 | 29 | 30 |
| 45.0 | 130 | 135 | 130 | 105 | 85 | 60 | 48 | 45 | 47 | 47 | 37 | 33 | 32 | 35 | 30 | 28 | 25 |
| 42.5 | 110 | 113 | 110 | 90 | 70 | 53 | 42 | 38 | 40 | 42 | 33 | 29 | 27 | 27 | 25 | 25 | 26 |
| 40.0 | 90 | 90 | 90 | 75 | 55 | 45 | 35 | 36 | 34 | 36 | 28 | 24 | 21 | 19 | 20 | 21 | 22 |
| 37.5 | 88 | 88 | 83 | 66 | 49 | 38 | 30 | 25 | 27 | 20 | 23 | 21 | 19 | 18 | 19 | 21 | 22 |
| 35.0 | 85 | 85 | 75 | 57 | 43 | 31 | 26 | 20 | 20 | 22 | 18 | 17 | [illegible] | 16 | 18 | 20 | 21 |
| 32.5 | 75 | 73 | 64 | 52 | 40 | 28 | 23 | 19 | 18 | 19 | 15 | 13 | 13 | 13 | 15 | 18 | 18 |
| 30.0 | 65 | 60 | 52 | 46 | 37 | 25 | 21 | 13 | 15 | 15 | 12 | 9 | 9 | 10 | 11 | 12 | 14 |

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TABLE 11. Covariance of zonal and meridional wind speed ($10^1\ m^2 sec^{-2}$).

SEASON:WINTER COV U-V

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | -35 | -20 | -10 | 10 | 15 | 20 | 20 | 20 | 25 | 10 | 5 | 5 | 4 | 3 | [illegible] | -2 | -5 |
| 57.5 | 200 | 203 | 200 | 205 | 195 | 173 | 165 | 175 | 333 | 285 | 203 | 123 | -12 | -33 | -9 | 4 | 18 |
| 55.0 | 450 | 425 | 425 | 400 | 375 | 325 | 310 | 330 | 650 | 560 | 400 | 240 | -30 | -70 | -20 | 10 | 25 |
| 52.5 | 1100 | 1013 | 913 | 775 | 638 | 413 | 355 | 403 | 700 | 510 | 325 | 170 | -37 | -74 | -44 | -2 | 14 |
| 50.0 | 1750 | 1600 | 1600 | 1150 | 900 | 500 | 400 | 475 | 750 | 460 | 50 | 100 | -45 | -80 | -70 | -15 | 10 |
| 47.5 | 1925 | 1875 | 1650 | 1355 | 1090 | 750 | 475 | 538 | 675 | 455 | 315 | 165 | 5 | -54 | -44 | -39 | -17 |
| 45.0 | 2100 | 2150 | 1900 | 1560 | 1280 | 1000 | 550 | 600 | 1000 | 450 | 140 | 110 | 55 | -30 | -60 | -65 | -45 |
| 42.5 | 1390 | 1575 | 1625 | 1430 | 1265 | 1100 | 825 | 825 | 1025 | 475 | 190 | 135 | 83 | 18 | -32 | -49 | -57 |
| 40.0 | 600 | 1000 | 1350 | 1300 | 1255 | 1200 | 1100 | 1050 | 1050 | 500 | 400 | 160 | 110 | 65 | -5 | -35 | -70 |
| 37.5 | 315 | 550 | 880 | 1100 | 1185 | 1200 | 1150 | 1025 | 850 | 425 | 295 | 155 | 125 | 78 | 8 | -26 | -64 |
| 35.0 | -50 | 100 | 425 | 900 | 1120 | 1200 | 1200 | 1000 | 650 | 350 | 310 | 150 | 140 | 90 | 20 | -15 | -60 |
| 32.5 | -174 | -59 | 143 | 600 | 810 | 925 | 950 | 820 | 560 | 300 | 261 | 165 | 118 | 65 | 15 | -12 | -62 |
| 30.0 | -300 | -220 | -140 | 300 | 500 | 550 | 700 | 640 | 470 | 250 | 195 | 140 | 95 | 40 | 10 | -10 | -65 |

SEASON:SPRING

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | -260 | -260 | -175 | -80 | 110 | 320 | 400 | 350 | 250 | 170 | 60 | 25 | 25 | 20 | 5 | -30 | -80 |
| 57.5 | -284 | -207 | -149 | -92 | 50 | 220 | 285 | 290 | 275 | 133 | 65 | 18 | 3 | -29 | -27 | -34 | -52 |
| 55.0 | -150 | -155 | -125 | -105 | -19 | 120 | 170 | 230 | 300 | 45 | 50 | 10 | -20 | -80 | -60 | -40 | -25 |
| 52.5 | -179 | -172 | -124 | -77 | 53 | 130 | 160 | 173 | 195 | 81 | 48 | 18 | -7 | -54 | -54 | -34 | -27 |
| 50.0 | -2[illegible]0 | -190 | -135 | -50 | 115 | 140 | 150 | 115 | 90 | 70 | 45 | 25 | 5 | -30 | -50 | -30 | -30 |
| 47.5 | -192 | -152 | -67 | 45 | 143 | 150 | 135 | 105 | 83 | 68 | 53 | 43 | 23 | -9 | -32 | -27 | -29 |
| 45.0 | -175 | -115 | 0 | 140 | 170 | 160 | 120 | 95 | 75 | 65 | 60 | 60 | 40 | 10 | -15 | -25 | -30 |
| 42.5 | -82 | 23 | 103 | 190 | 190 | 168 | 130 | 100 | 85 | 58 | 60 | 58 | 43 | 15 | -2 | -12 | -17 |
| 40.0 | 10 | 160 | 205 | 240 | 210 | 175 | 140 | 105 | 95 | 50 | 60 | 55 | 45 | 20 | 10 | 0 | -5 |
| 37.5 | 143 | 210 | 210 | 208 | 168 | 140 | 125 | 108 | 90 | 45 | 53 | 45 | 38 | 20 | 13 | 6 | 3 |
| 35.0 | 275 | 260 | 215 | 175 | 125 | 105 | 110 | 110 | 85 | 40 | 45 | 35 | 30 | 20 | 15 | 15 | 10 |
| 32.5 | 238 | 215 | 165 | 83 | 48 | 33 | 58 | 75 | 78 | 45 | 43 | 35 | 30 | 18 | 15 | 1[illegible] | 8 |
| 30.0 | 200 | 170 | 115 | -10 | -30 | -40 | 5 | 40 | 70 | 50 | 40 | 35 | 30 | 15 | 15 | 10 | 5 |

SEASON:SUMMER

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 120 | 40 | -20 | -25 | -25 | -20 | -5 | 20 | 35 | 35 | 25 | 20 | 15 | 15 | 10 | 5 | 5 |
| 57.5 | 75 | 23 | -12 | -22 | -29 | -29 | -24 | -17 | -14 | -17 | -24 | -24 | -22 | -17 | -14 | -12 | -7 |
| 55.0 | 30 | 5 | -5 | -20 | -35 | -40 | -45 | -55 | -65 | -70 | -75 | -70 | -90 | -53 | -60 | -30 | -20 |
| 52.5 | 28 | 8 | -3 | -14 | -29 | -34 | -39 | -47 | -47 | -44 | -47 | -49 | -39 | -32 | -22 | -14 | 0 |
| 50.0 | 25 | 10 | -2 | -10 | -25 | -30 | -35 | -40 | -30 | -20 | -20 | -10 | -20 | -15 | -5 | 0 | 20 |
| 47.5 | 23 | 13 | 2 | -4 | -13 | -17 | -19 | -20 | -13 | -7 | -9 | -19 | -29 | -19 | -6 | 3 | 25 |
| 45.0 | 20 | 15 | 5 | 0 | -3 | -5 | -5 | -1 | 2 | 4 | 0 | -10 | -20 | -25 | -8 | 5 | 30 |
| 42.5 | 20 | 18 | 10 | 5 | 1 | 0 | 5 | 10 | 11 | 10 | 1 | -8 | -17 | -27 | -18 | -4 | 10 |
| 40.0 | 20 | 20 | 15 | 10 | 5 | 5 | 15 | 20 | 20 | 15 | 2 | -8 | -15 | -30 | -30 | -15 | -10 |
| 37.5 | 13 | 14 | 11 | 10 | 7 | 5 | 8 | 8 | 13 | 13 | 4 | -8 | -17 | -22 | -24 | -12 | -4 |
| 35.0 | 5 | 8 | 10 | 10 | 8 | 5 | 6 | -5 | 5 | 10 | 5 | -10 | -20 | -15 | -15 | -10 | 6 |
| 32.5 | 3 | 6 | 8 | 8 | 4 | 0 | -1 | -5 | 4 | 4 | 4 | -6 | -12 | -7 | -5 | [illegible] | 1[illegible] |
| 30.0 | 1 | 3 | 5 | 5 | 0 | -5 | -8 | -7 | 2 | 6 | 3 | -3 | -5 | -1 | 3 | 12 | 20 |

SEASON:AUTUMN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | -7 | -5 | -3 | -7 | -8 | -4 | 2 | 8 | 15 | 15 | 5 | 5 | 10 | 15 | 15 | 5 | 0 |
| 57.5 | 172 | 168 | 156 | 132 | 136 | 128 | 114 | 109 | 98 | 18 | -7 | -17 | -34 | -37 | -32 | -22 | -9 |
| 55.0 | 350 | 340 | 315 | 290 | 280 | 260 | 225 | 210 | 180 | 20 | -20 | -40 | -80 | -90 | -80 | -50 | -20 |
| 52.5 | 333 | 333 | 318 | 300 | 285 | 265 | 238 | 220 | 190 | 40 | 5 | -34 | -64 | -74 | -64 | -39 | -17 |
| 50.0 | 315 | 325 | 320 | 310 | 29[illegible] | 270 | 250 | 230 | 200 | 140 | 30 | -30 | -50 | -60 | -50 | -30 | -15 |
| 47.5 | 288 | 303 | 310 | 300 | 295 | 273 | 245 | 223 | 188 | 133 | 48 | -19 | -37 | -42 | -34 | -24 | -19 |
| 45.0 | 260 | 280 | 300 | 305 | 300 | 275 | 240 | 215 | 175 | 125 | 65 | -10 | -25 | -25 | -20 | -20 | -25 |
| 42.5 | 225 | 240 | 263 | 273 | 270 | 248 | 223 | 193 | 135 | 90 | 43 | -7 | -19 | -22 | -22 | -22 | -27 |
| 40.0 | 190 | 200 | 225 | 240 | 240 | 220 | 205 | 170 | 95 | 55 | 20 | -5 | -15 | -20 | -25 | -25 | -30 |
| 37.5 | 158 | 170 | 188 | 203 | 200 | 170 | 153 | 135 | 103 | 45 | 5 | -14 | -19 | -19 | -17 | -12 | -14 |
| 35.0 | 125 | 140 | 150 | 165 | 169 | 120 | 100 | 100 | 113 | 35 | -10 | -25 | -25 | -20 | -10 | 0 | 0 |
| 32.5 | 103 | 115 | 125 | 138 | 135 | 105 | 95 | 93 | 100 | 43 | -12 | -22 | -22 | -14 | -2 | 8 | 15 |
| 30.0 | 80 | 90 | 100 | 110 | 110 | 90 | 75 | 65 | 105 | 50 | -15 | -20 | -20 | -10 | 5 | 15 | 30 |

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TABLE 12. Covariance of temperature and meridional wind speed ($10^1$ m $^\circ$K sec$^{-1}$).

SEASON:WINTER COV V-T

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 70 | 60 | 70 | 75 | 80 | 70 | 60 | 65 | 70 | 56 | 10 | -5 | -10 | -5 | 5 | 10 | 25 |
| 57.5 | -49 | -49 | -29 | -17 | -9 | 10 | 25 | 43 | 95 | 50 | 0 | -12 | -24 | -17 | -12 | -7 | -2 |
| 55.0 | -170 | -160 | -130 | -110 | -100 | -50 | -10 | 100 | 120 | 50 | -10 | -20 | -40 | -30 | -30 | -25 | -30 |
| 52.5 | -142 | -129 | -84 | -42 | 0 | 30 | 60 | 115 | 100 | 35 | 20 | -9 | -27 | -22 | -24 | -22 | -22 |
| 50.0 | -115 | -100 | -60 | 25 | 100 | 110 | 130 | 130 | 80 | 68 | 50 | 0 | -15 | -15 | -20 | -20 | -15 |
| 47.5 | 45 | 53 | 80 | 103 | 138 | 145 | 155 | 140 | 65 | 25 | 30 | 20 | 8 | 3 | -2 | -4 | -9 |
| 45.0 | 205 | 205 | 200 | 180 | 175 | 180 | 180 | 150 | 50 | -10 | 15 | 40 | 30 | 20 | 15 | 10 | -5 |
| 42.5 | 178 | 210 | 215 | 210 | 213 | 220 | 220 | 195 | 80 | -9 | -2 | 13 | 13 | 19 | 8 | 0 | -3 |
| 40.0 | 150 | 215 | 230 | 240 | 250 | 260 | 260 | 240 | 125 | -10 | -15 | -15 | -5 | 0 | 0 | -10 | -15 |
| 37.5 | 25 | 143 | 175 | 195 | 208 | 230 | 283 | 270 | 110 | -4 | -12 | -7 | 0 | 3 | 3 | -4 | -7 |
| 35.0 | -100 | 70 | 120 | 150 | 165 | 200 | 305 | 315 | 95 | 0 | -10 | 0 | 5 | 5 | 5 | 0 | 0 |
| 32.5 | -49 | 50 | 90 | 110 | 130 | 150 | 205 | 243 | 78 | 5 | -12 | -4 | 5 | 8 | 8 | 3 | 3 |
| 30.0 | 0 | 30 | 60 | 70 | 95 | 100 | 165 | 96 | 60 | 10 | -15 | -10 | 5 | 10 | 10 | 5 | 5 |

SEASON:SPRING

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 60 | 50 | 45 | 45 | 50 | 40 | 40 | 35 | 20 | 5 | -5 | -5 | -3 | 2 | 4 | 1 | 5 |
| 57.5 | 53 | 45 | 40 | 40 | 40 | 35 | 30 | 40 | 40 | 30 | -2 | -12 | -1 | 2 | -2 | -7 | -12 |
| 55.0 | 45 | 40 | 35 | 35 | 30 | 30 | 35 | 45 | [illegible] | 55 | 0 | -20 | 0 | 2 | -10 | -20 | -30 |
| 52.5 | 65 | 58 | 48 | 46 | 43 | 40 | 30 | 40 | 60 | 53 | 0 | -2 | 10 | 11 | -2 | -12 | -22 |
| 50.0 | 85 | 75 | 60 | 60 | 55 | 50 | 40 | 35 | 45 | 50 | 0 | 15 | 20 | 20 | 5 | -5 | -15 |
| 47.5 | 130 | 100 | 80 | 70 | 63 | 60 | 50 | 43 | 45 | 45 | 13 | 10 | 20 | 20 | 10 | 0 | -4 |
| 45.0 | 175 | 125 | 100 | 80 | 70 | 70 | 60 | 50 | 45 | 40 | 25 | 20 | 23 | 20 | 15 | 5 | -5 |
| 42.5 | 168 | 140 | 115 | 90 | 85 | 75 | 60 | 51 | 45 | 40 | 23 | 20 | 10 | 10 | 14 | 4 | -1 |
| 40.0 | 160 | 155 | 130 | 115 | 100 | 80 | 80 | 52 | 45 | 40 | 20 | 20 | 15 | 15 | 12 | 7 | 2 |
| 37.5 | 80 | 103 | 100 | 105 | 95 | 73 | 56 | 49 | 35 | 30 | 13 | 13 | 13 | 13 | 4 | 4 | 1 |
| 35.0 | 0 | 50 | 70 | 95 | 90 | 65 | 52 | 45 | 25 | 20 | 5 | 5 | 10 | 10 | 4 | 1 | -1 |
| 32.5 | -17 | 25 | 53 | 75 | 75 | 57 | 46 | 35 | 20 | 10 | 3 | 1 | 7 | 7 | 2 | 0 | -1 |
| 30.0 | -35 | 0 | 35 | 55 | 60 | 40 | 40 | 25 | 15 | 15 | 0 | -3 | 3 | 4 | 0 | -1 | -2 |

SEASON:SUMMER

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | -40 | -15 | 5 | 15 | 15 | 12 | 10 | 7 | 7 | 5 | 5 | 2 | -2 | -2 | 0 | 1 | 1 |
| 57.5 | 10 | 25 | 33 | 35 | 35 | 39 | 43 | 44 | 51 | 53 | 33 | 21 | 4 | 0 | 0 | -4 | -14 |
| 55.0 | 75 | 65 | 60 | 55 | 55 | 65 | 75 | 80 | 95 | 100 | 60 | 40 | 10 | 0 | 0 | -15 | -30 |
| 52.5 | 58 | 40 | 43 | 40 | 45 | 55 | 63 | 68 | 78 | 63 | 23 | 0 | -12 | 0 | 3 | -4 | -14 |
| 50.0 | 40 | 30 | 25 | 25 | 35 | 45 | 50 | 55 | 60 | 25 | -15 | -40 | -35 | 0 | 5 | 5 | 0 |
| 47.5 | 33 | 28 | 23 | 23 | 28 | 35 | 43 | 48 | 53 | 25 | -7 | -22 | -19 | -2 | -2 | -4 | -9 |
| 45.0 | 25 | 25 | 20 | 20 | 20 | 25 | 35 | 40 | 45 | 25 | 0 | -5 | -5 | -5 | -16 | -15 | -20 |
| 42.5 | 28 | 20 | 18 | 18 | 18 | 23 | 28 | 33 | 35 | 38 | 15 | 10 | 0 | 5 | -2 | -7 | -14 |
| 40.0 | 15 | 15 | 15 | 15 | 15 | 26 | 20 | 25 | 25 | 35 | 30 | 25 | 20 | 15 | 5 | 0 | -10 |
| 37.5 | 13 | 13 | 13 | 13 | 13 | 16 | 17 | 20 | 21 | 28 | 25 | 22 | 17 | 13 | 5 | 2 | -3 |
| 35.0 | 10 | 10 | 10 | 10 | 11 | 12 | 13 | 14 | 10 | 20 | 20 | 10 | 14 | 10 | 5 | 1 | 2 |
| 32.5 | 9 | 9 | 8 | 8 | 9 | 10 | 11 | 12 | 14 | 16 | 10 | 14 | 11 | 9 | 6 | 5 | 6 |
| 30.0 | 7 | 7 | 6 | 6 | 7 | 7 | 8 | 9 | 11 | 11 | 12 | 10 | 8 | 8 | 6 | 6 | 5 |

SEASON:AUTUMN

| LATITUDE | 75 | 70 | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60.0 KM | 4 | 4 | 5 | 6 | 6 | 6 | 6 | 6 | 8 | 8 | 6 | 3 | 0 | -2 | 0 | 1 | 2 |
| 57.5 | -52 | -57 | -67 | -76 | -61 | -36 | 8 | 10 | 7 | 4 | 4 | -16 | -14 | -15 | -14 | -16 | -16 |
| 55.0 | -110 | -120 | -140 | -100 | -130 | -80 | 10 | 30 | 5 | 0 | 1 | -25 | -30 | -30 | -30 | -35 | -35 |
| 52.5 | -87 | -84 | -89 | -134 | -122 | -69 | 15 | 33 | 10 | -2 | 1 | -7 | -11 | -12 | -16 | -21 | -23 |
| 50.0 | -65 | -50 | -40 | -110 | -115 | -60 | 20 | 35 | 30 | -5 | 0 | 10 | 7 | 4 | -3 | -8 | -13 |
| 47.5 | -49 | -24 | 20 | -54 | -109 | -64 | 18 | 20 | 33 | -3 | -2 | 4 | 3 | 2 | -1 | -5 | -8 |
| 45.0 | -35 | 0 | 80 | 0 | -105 | -70 | 15 | 20 | 35 | -7 | -5 | -2 | -1 | 0 | -1 | -3 | -5 |
| 42.5 | -49 | 10 | 83 | 33 | -59 | -37 | 13 | 10 | 20 | -1 | 2 | 3 | 0 | -2 | -3 | -4 | -4 |
| 40.0 | -65 | 20 | 85 | 65 | -15 | -5 | 10 | 15 | 20 | -2 | 0 | 0 | -1 | -5 | -4 | -4 | -4 |
| 37.5 | -42 | 5 | 68 | 55 | 15 | 10 | 20 | 18 | 10 | -10 | 0 | 2 | 0 | -1 | 0 | 0 | 0 |
| 35.0 | -20 | -10 | 50 | 45 | 45 | 40 | 30 | 20 | 0 | -20 | -6 | -5 | 0 | 1 | 4 | 5 | 4 |
| 32.5 | -24 | -14 | 25 | 30 | 33 | 33 | 25 | 18 | 0 | -10 | 0 | 4 | 7 | 8 | 6 | 4 | 2 |
| 30.0 | -30 | -20 | 0 | 15 | 20 | 25 | 20 | 15 | 15 | -2 | 0 | 12 | 14 | 14 | 4 | 3 | -1 |

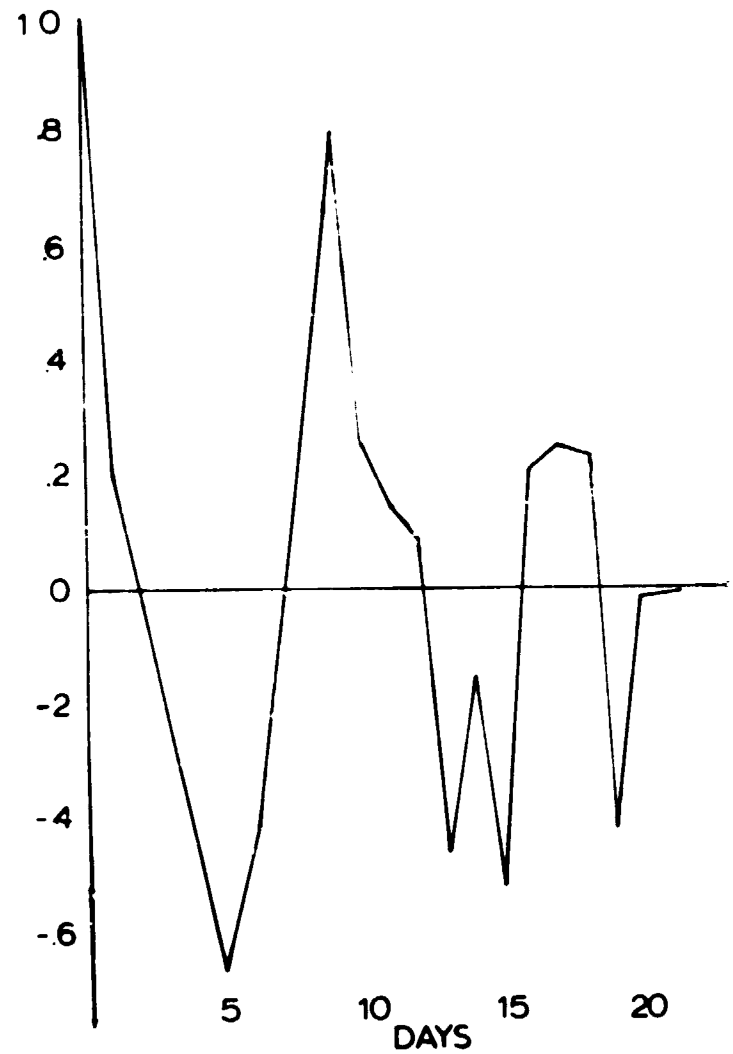
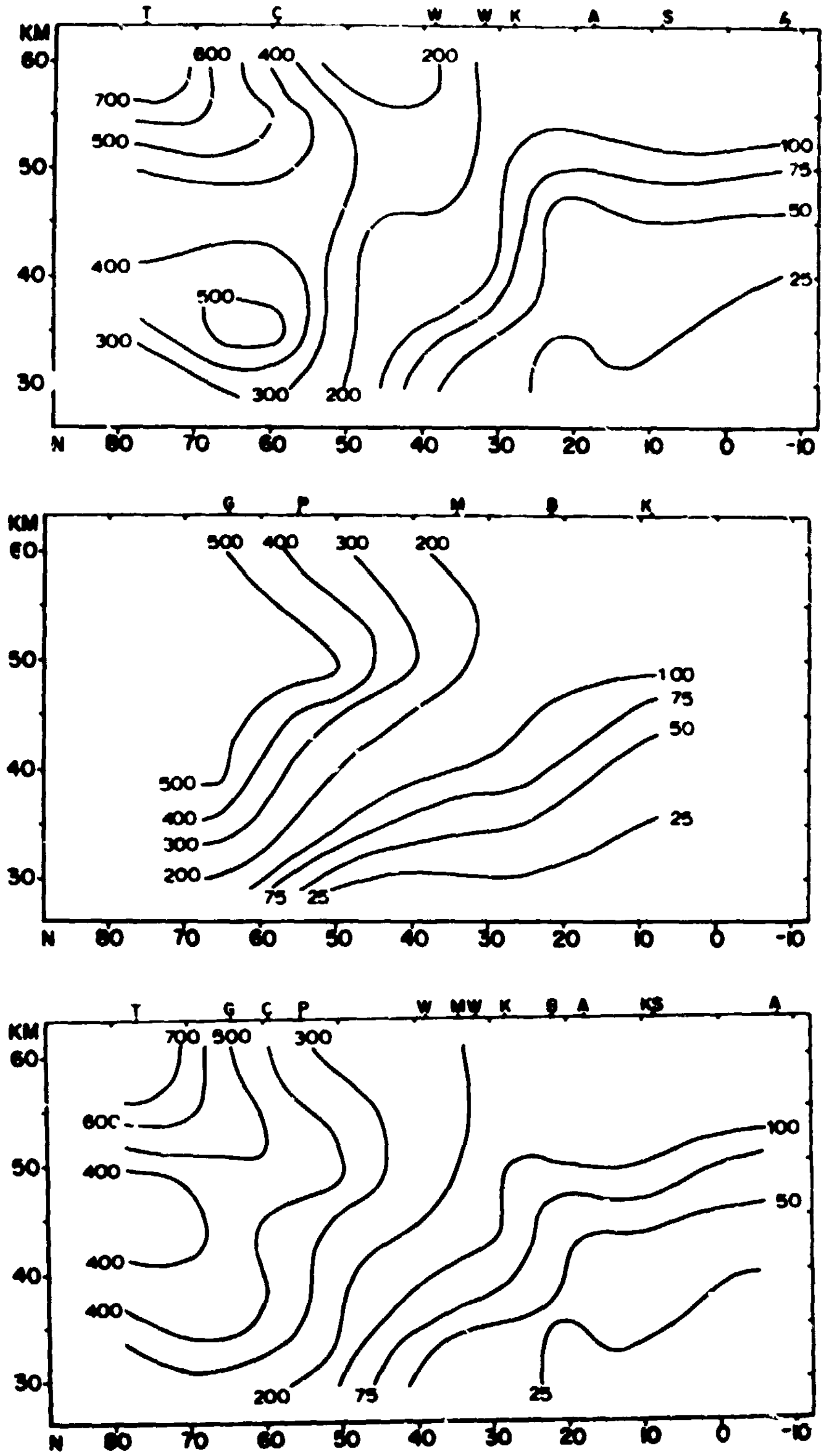
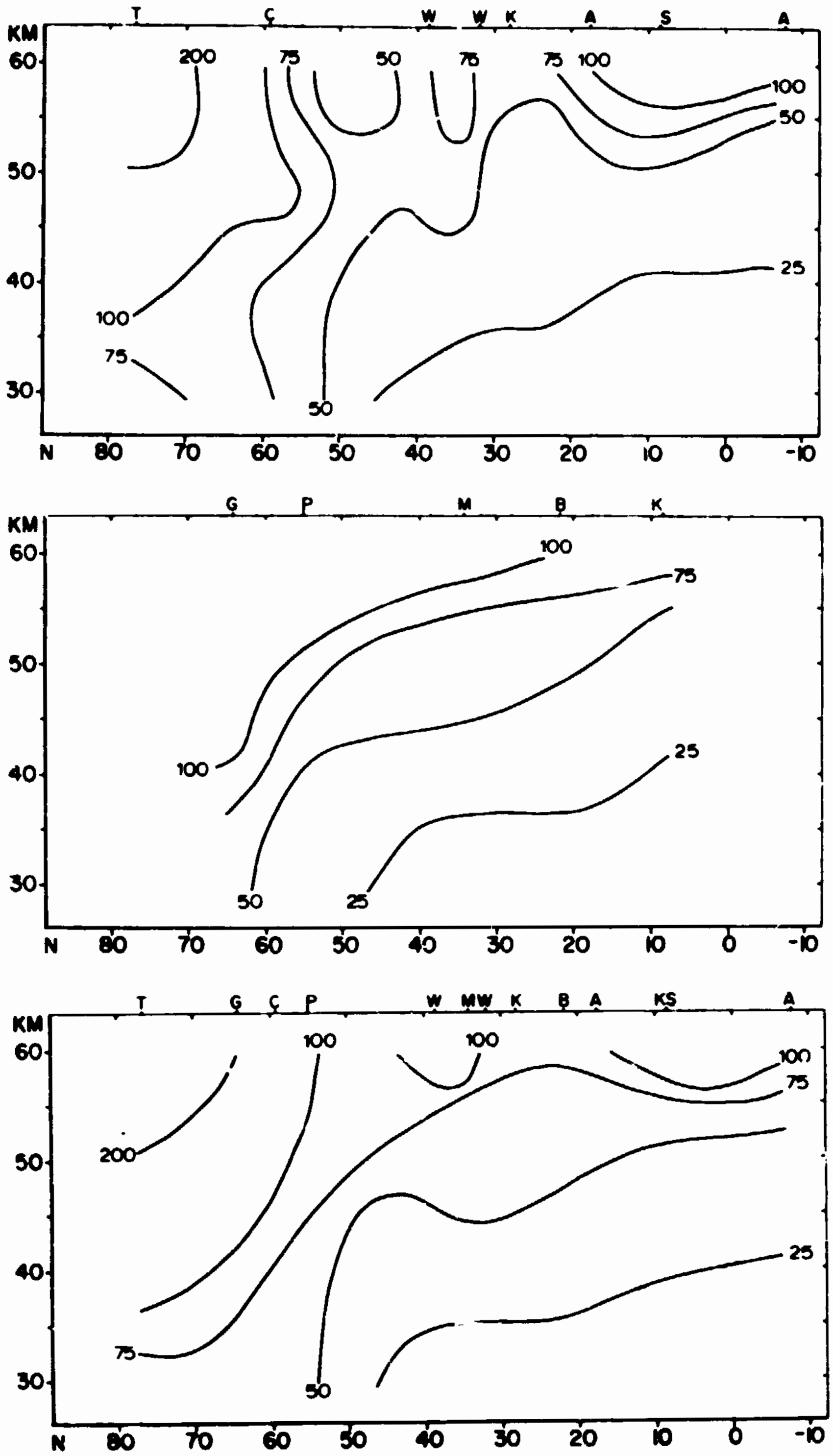



FIGURE 1. Time-lagged autocorrelation function at 30 km at White Sands (32N, 106W) during autumn, 1972.



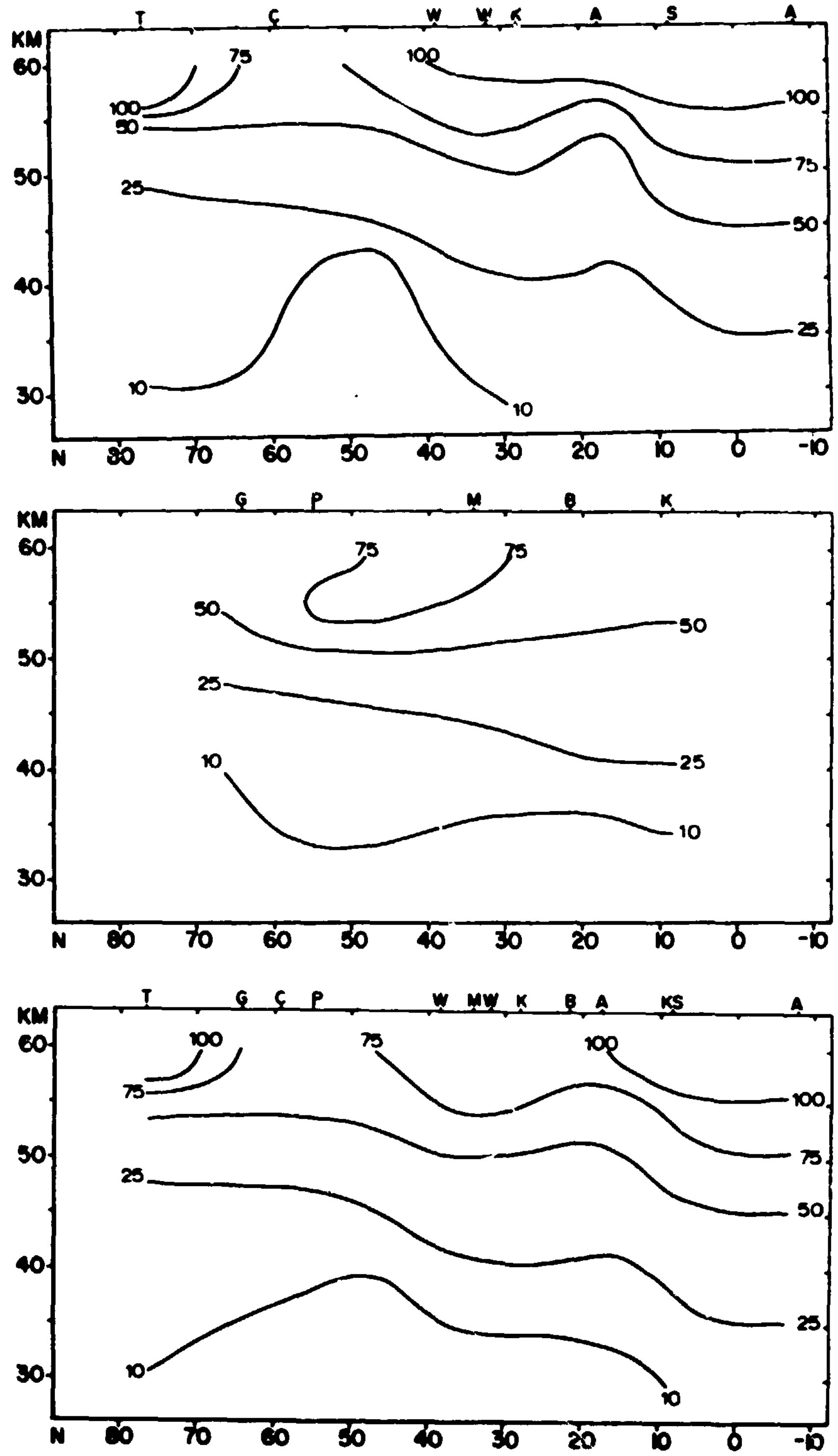
(a) WINTER

FIGURE 2. Seasonal values of Kyy ($10^4$ $m^2 sec^{-1}$). Top: 80°W, Center: 150°W, Bottom: mean.



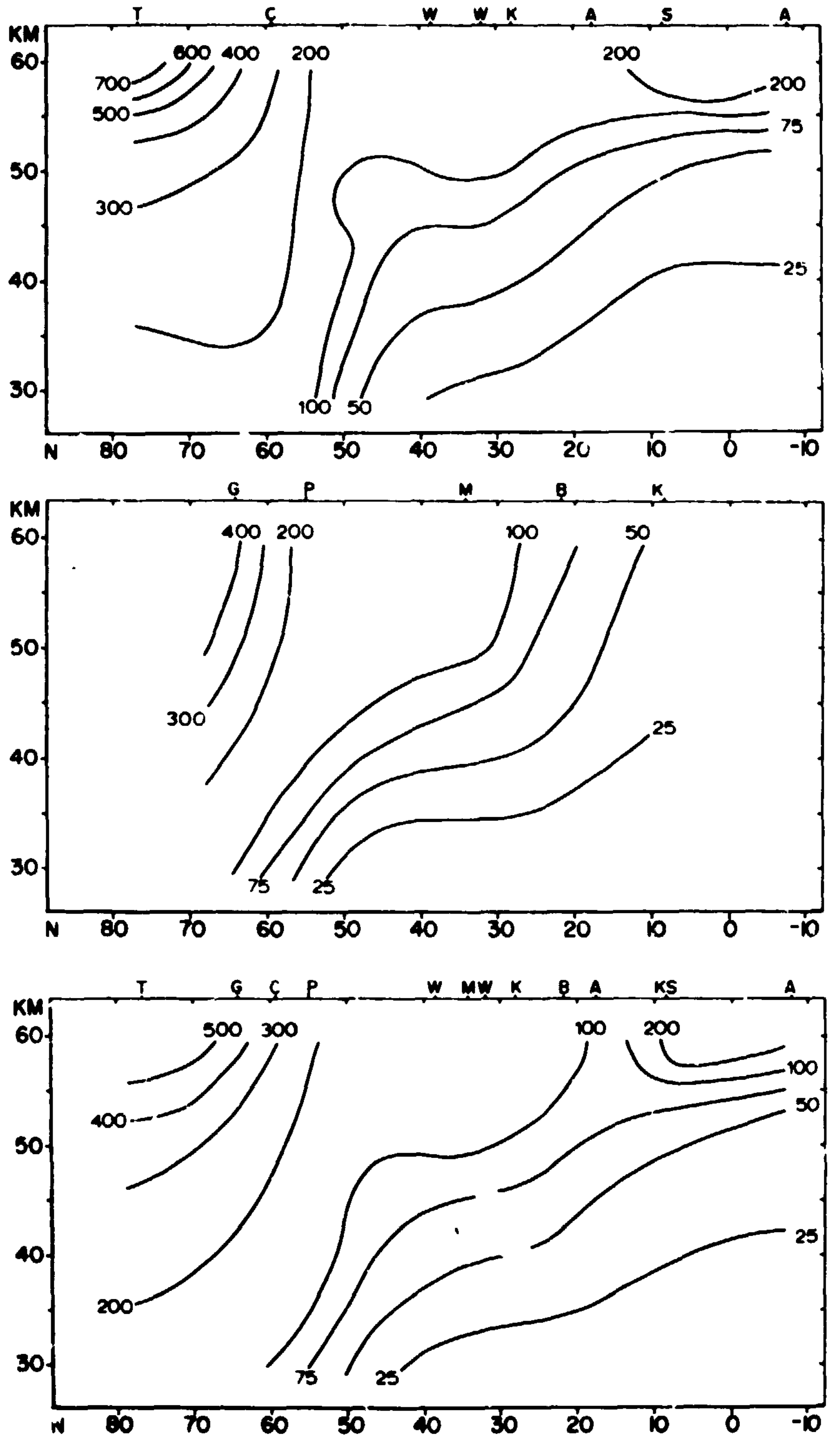

(b) SPRING

FIGURE 2. Continued.




(c) SUMMER

FIGURE 2. Continued.




(d) AUTUMN

FIGURE 2. Continued.

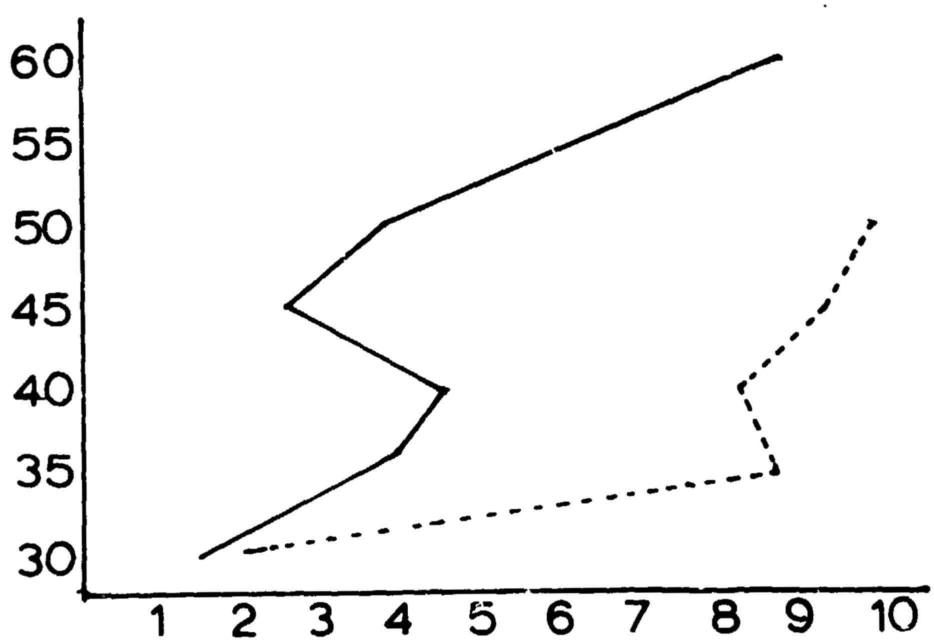
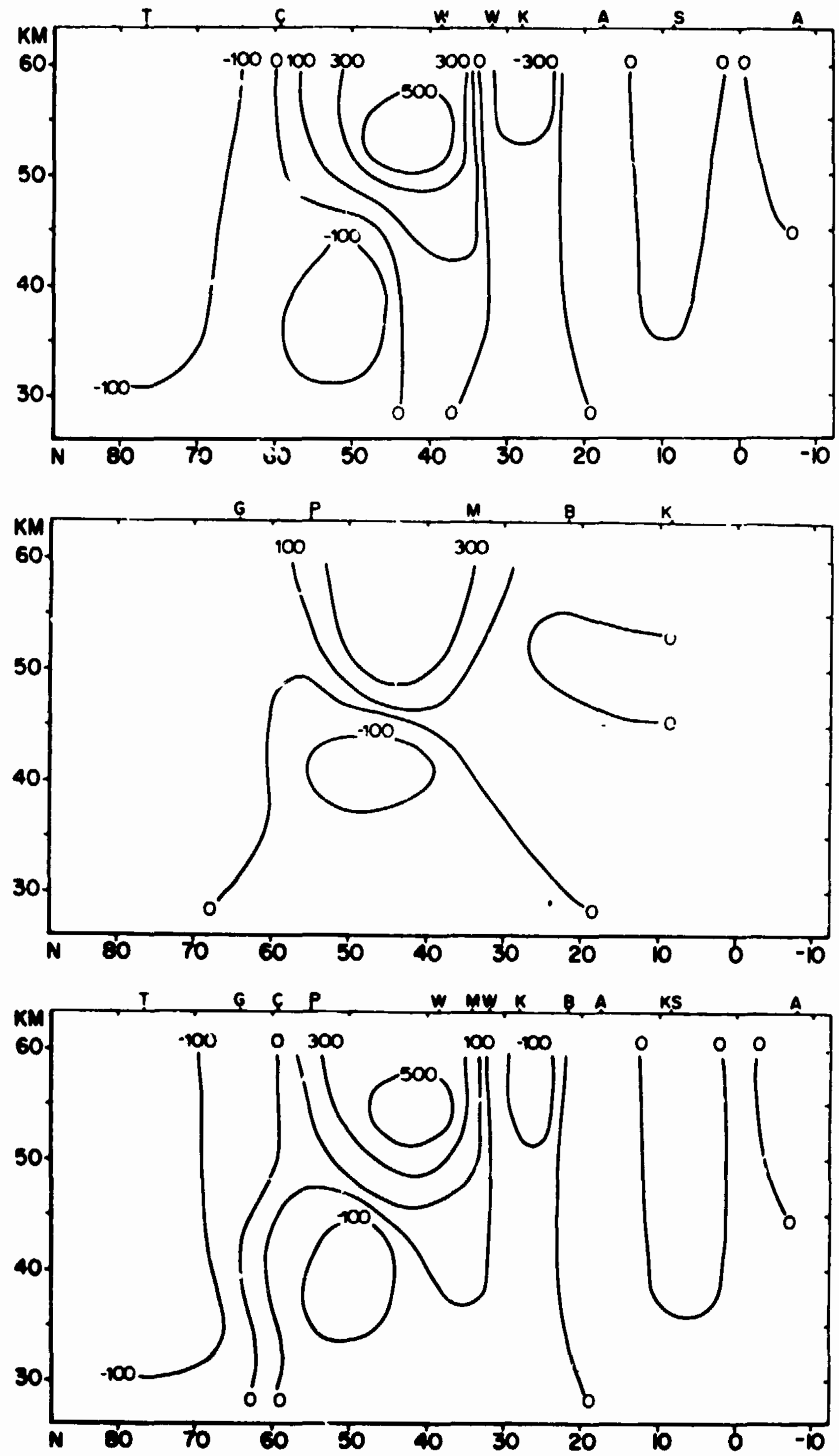
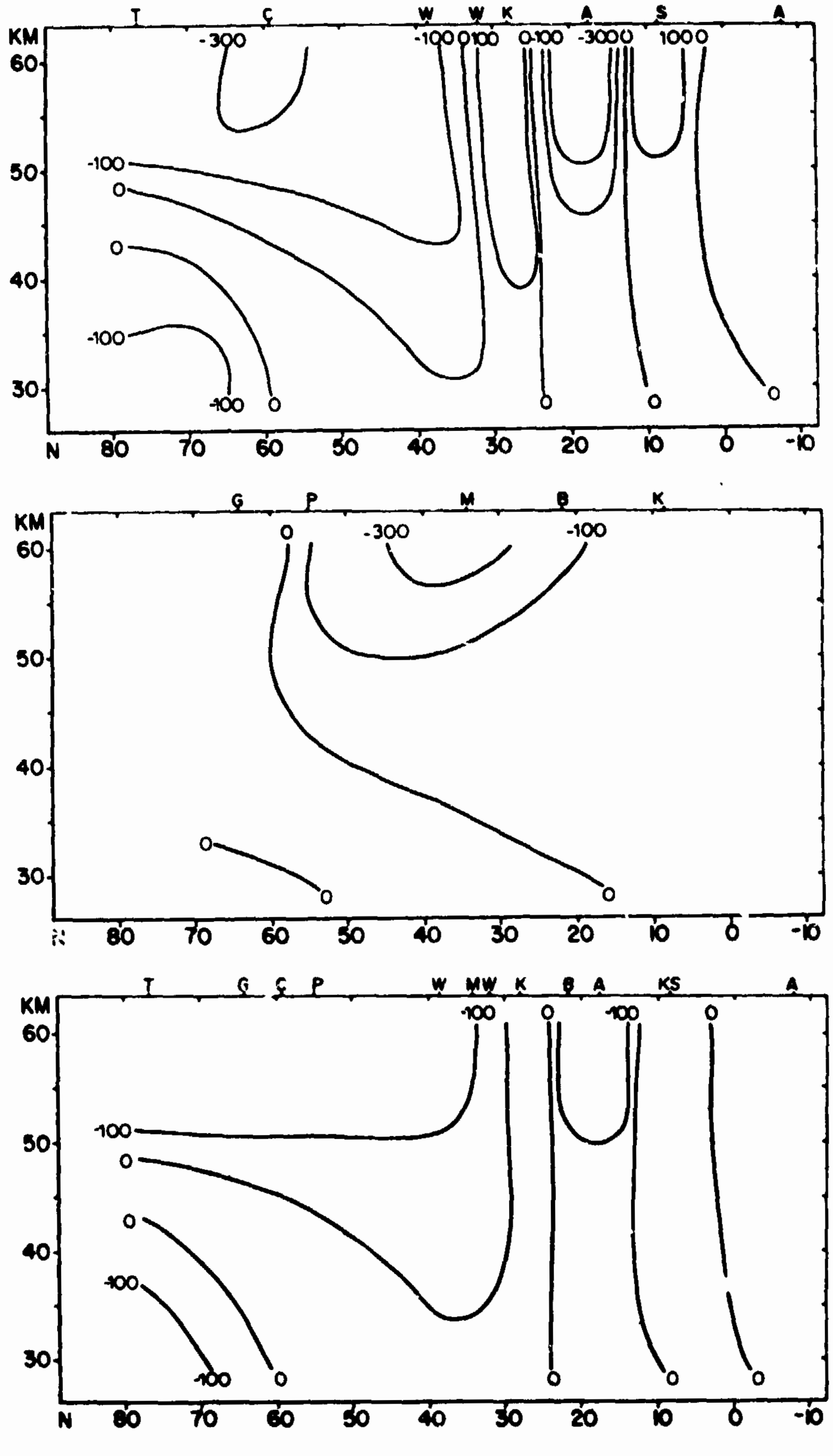



FIGURE 3. Comparison of $K_{yy}$ ($10^4\ m^2 sec^{-1}$) during winter at Thule (77N, 69W, solid line) and Heiss (91N, 58E, dotted line).



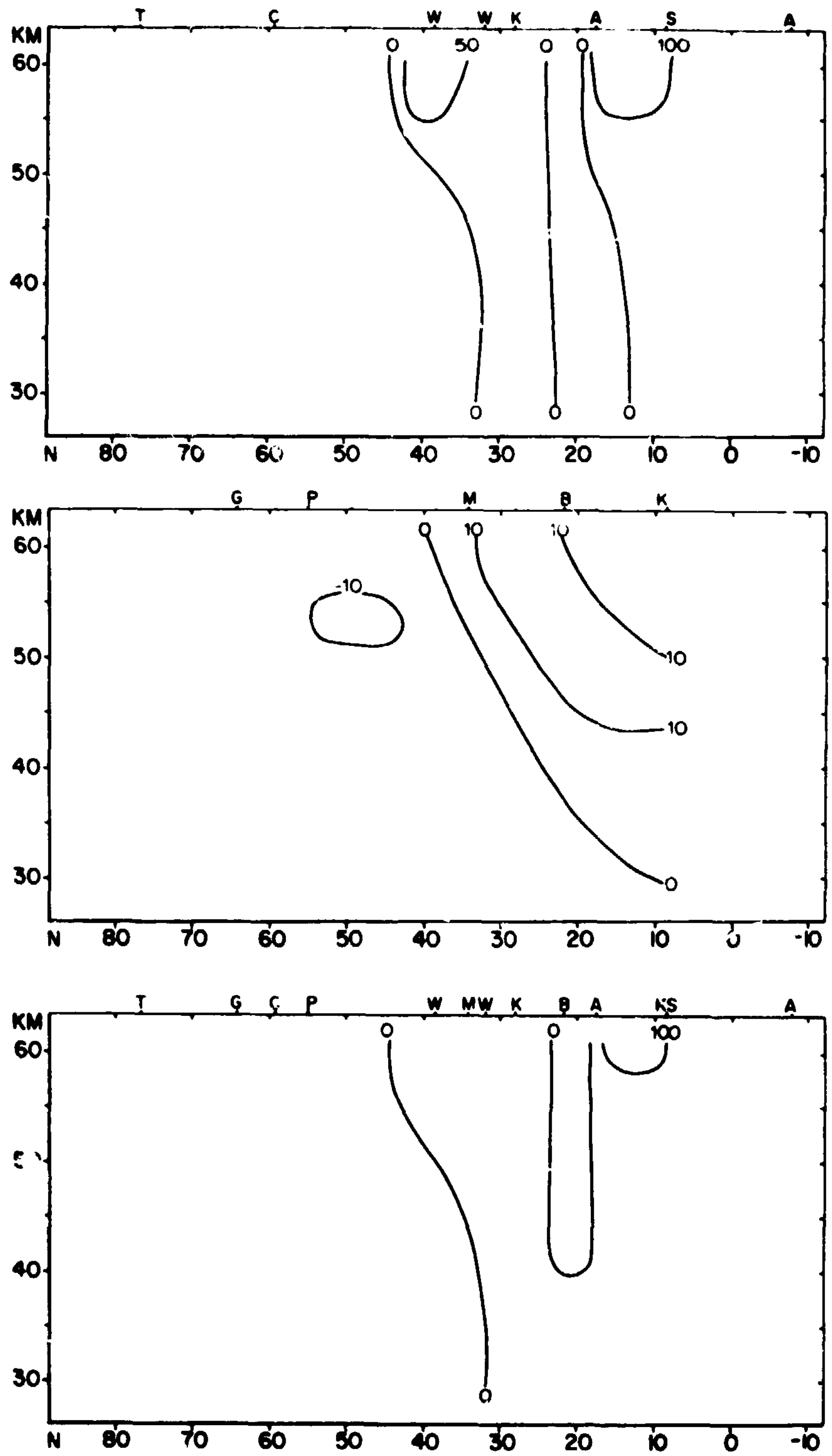

(a) WINTER

FIGURE 4. Seasonal values of $K_{yz}$ ($10^1$ $m^2 sec^{-1}$). Top: 80°W, Center: 150°W, Bottom: mean.



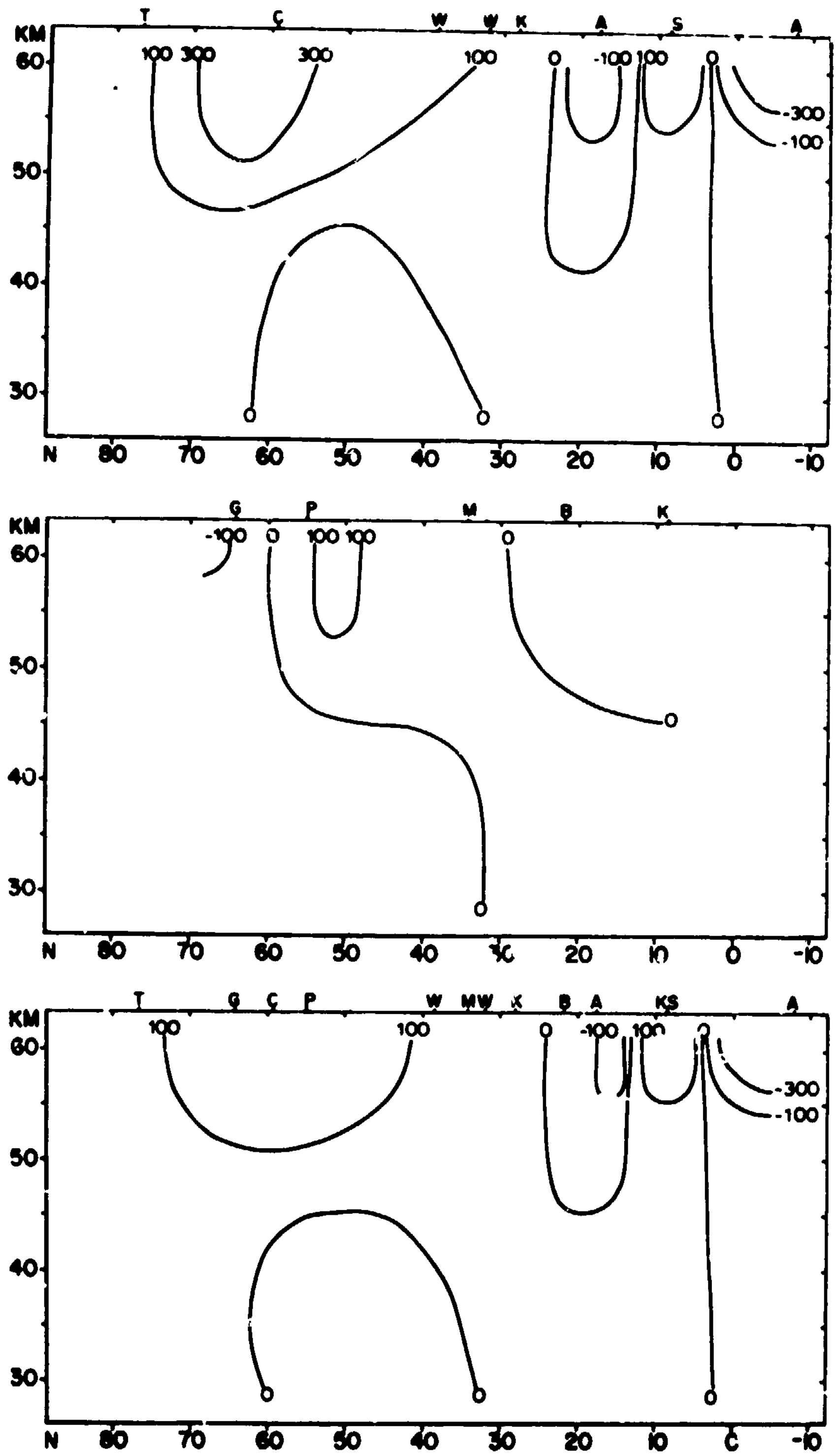

(b) SPRING

FIGURE 4. Continued.



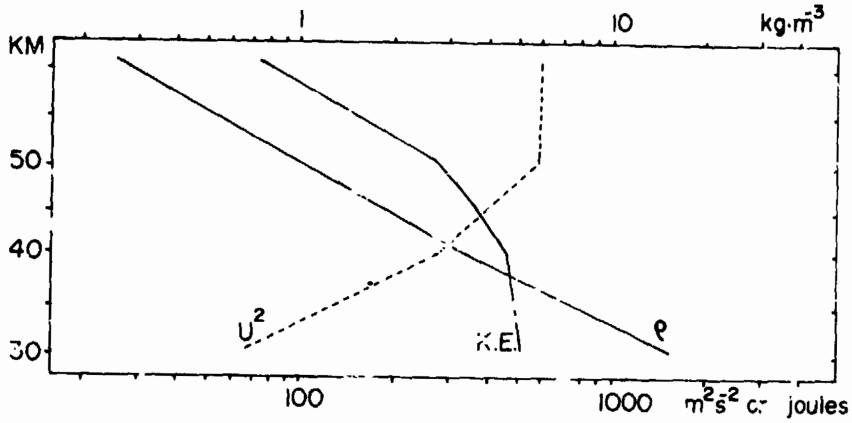

(c) SUMMER

FIGURE 4. Continued.




(d) AUTUMN

FIGURE 4. Continued.



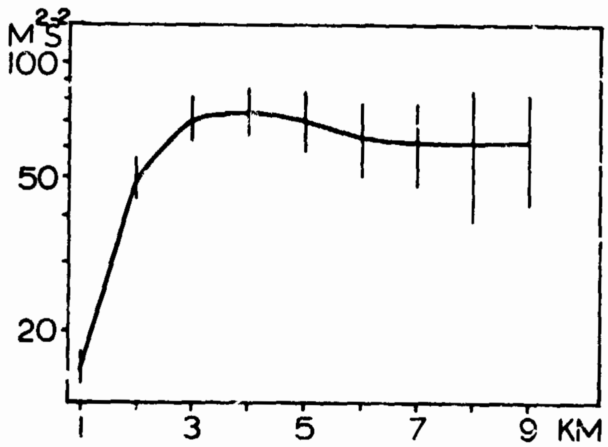
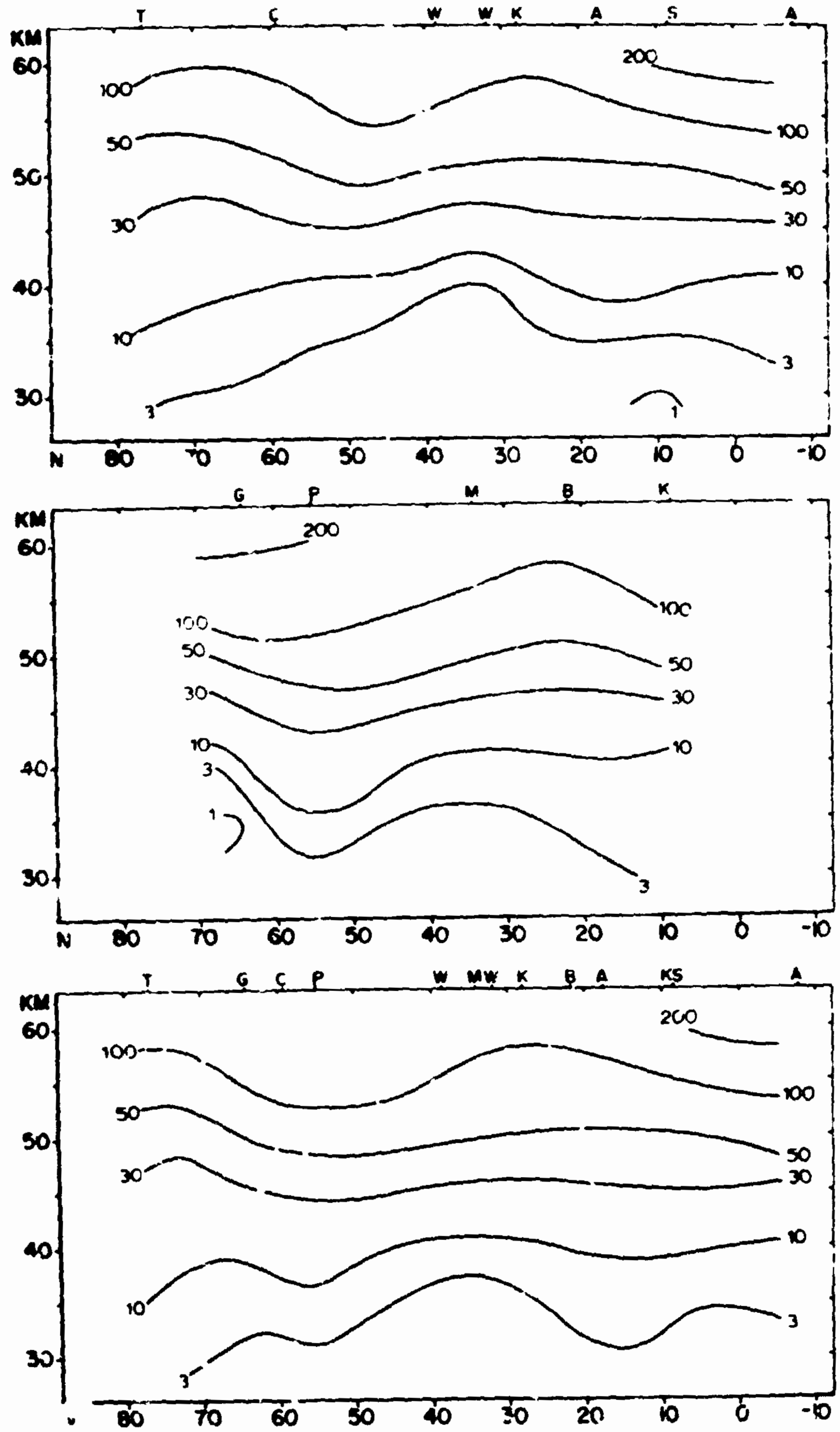
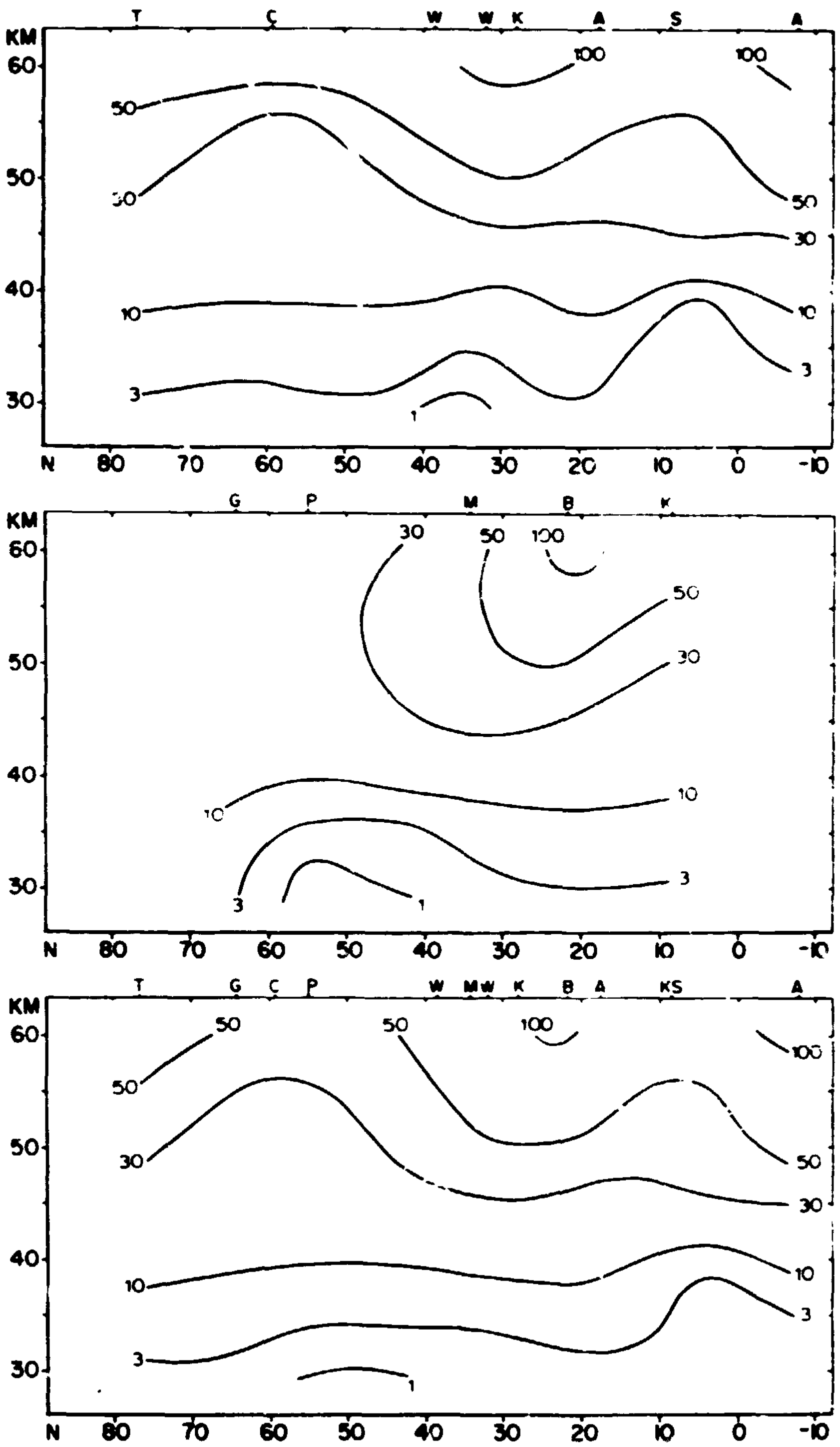




FIGURE 5. Examples of data used for estimating $K_{zz}$. (a) Vertical profiles of specific kinetic energy, density, and the square of the perturbation wind speed at Point Mugu during winter. (b) Magnitude of the vertical structure function (D(Z)) as a function of separation distance for the altitude range 52-64 km at Canaveral during autumn.



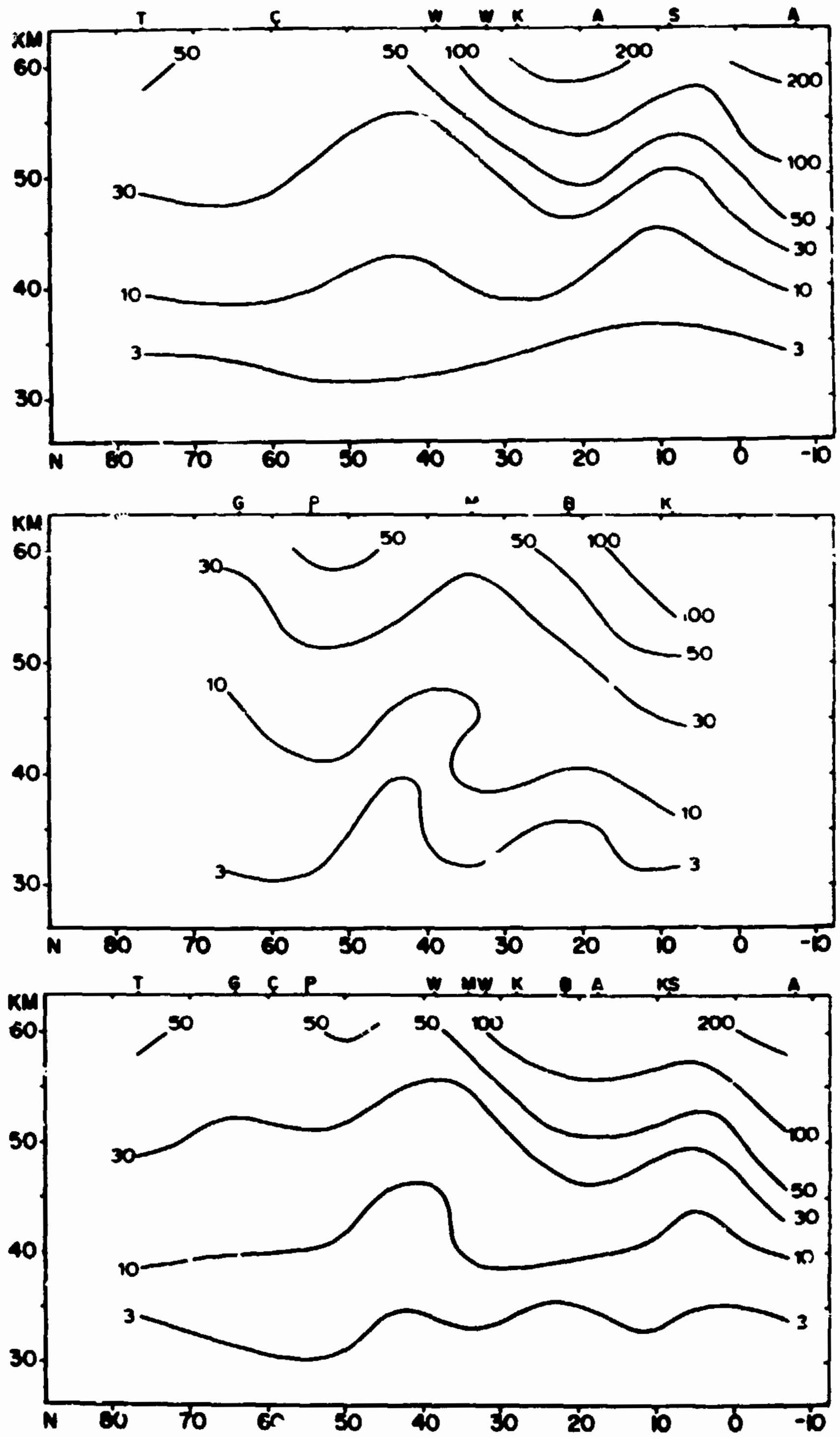

(a) WINTER

FIGURE ?. Seasonal values of $K_{zz}$ ($m^2 sec^{-1}$). Top: 80°W, Center: 150°?, Bottom: mean.



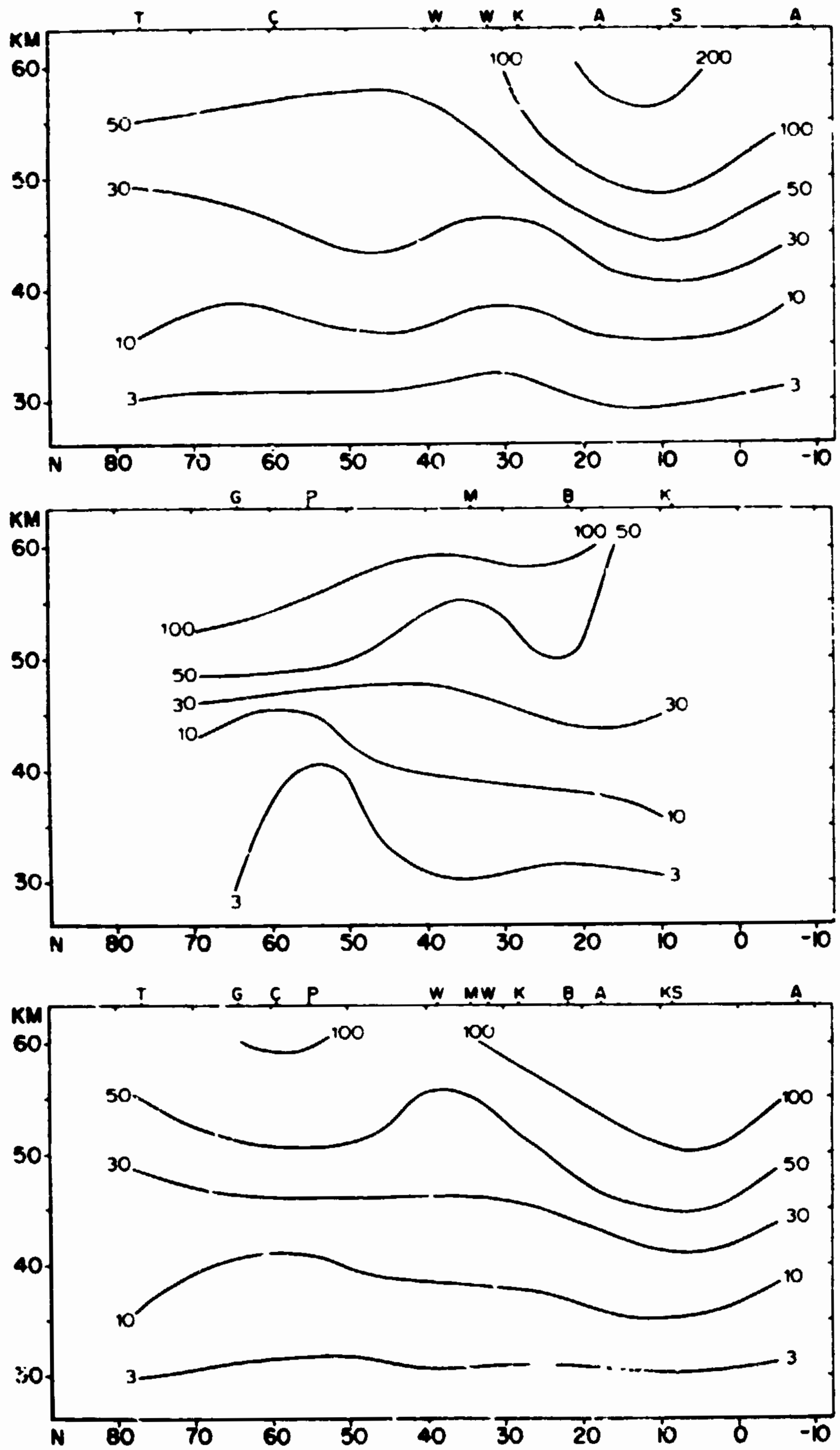
(b) SPRING

FIGURE 6. Continued.




(c) SUMMER

FIGURE 6. Continued.




(d) AUTUMN

FIGURE 6. Continued.

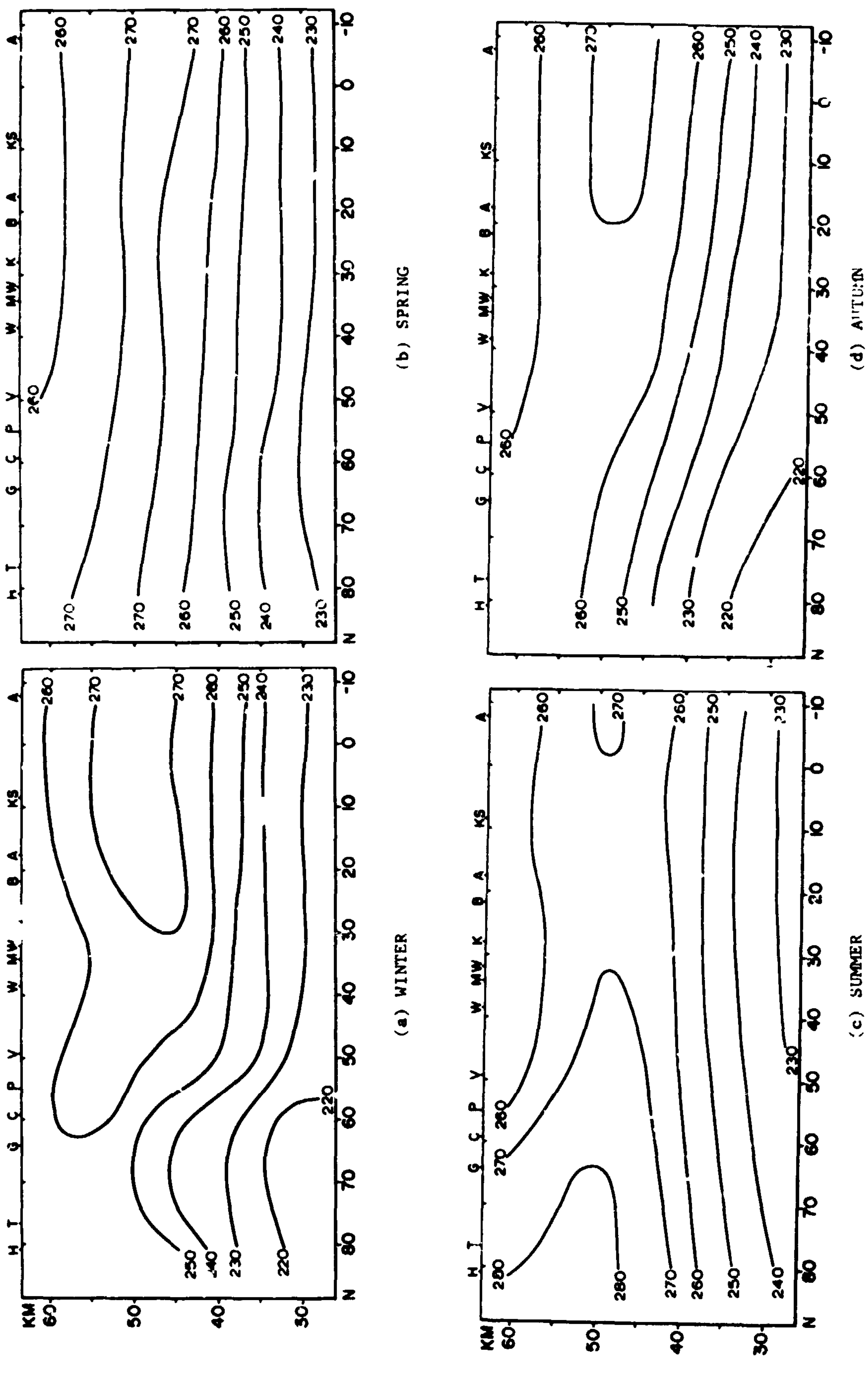
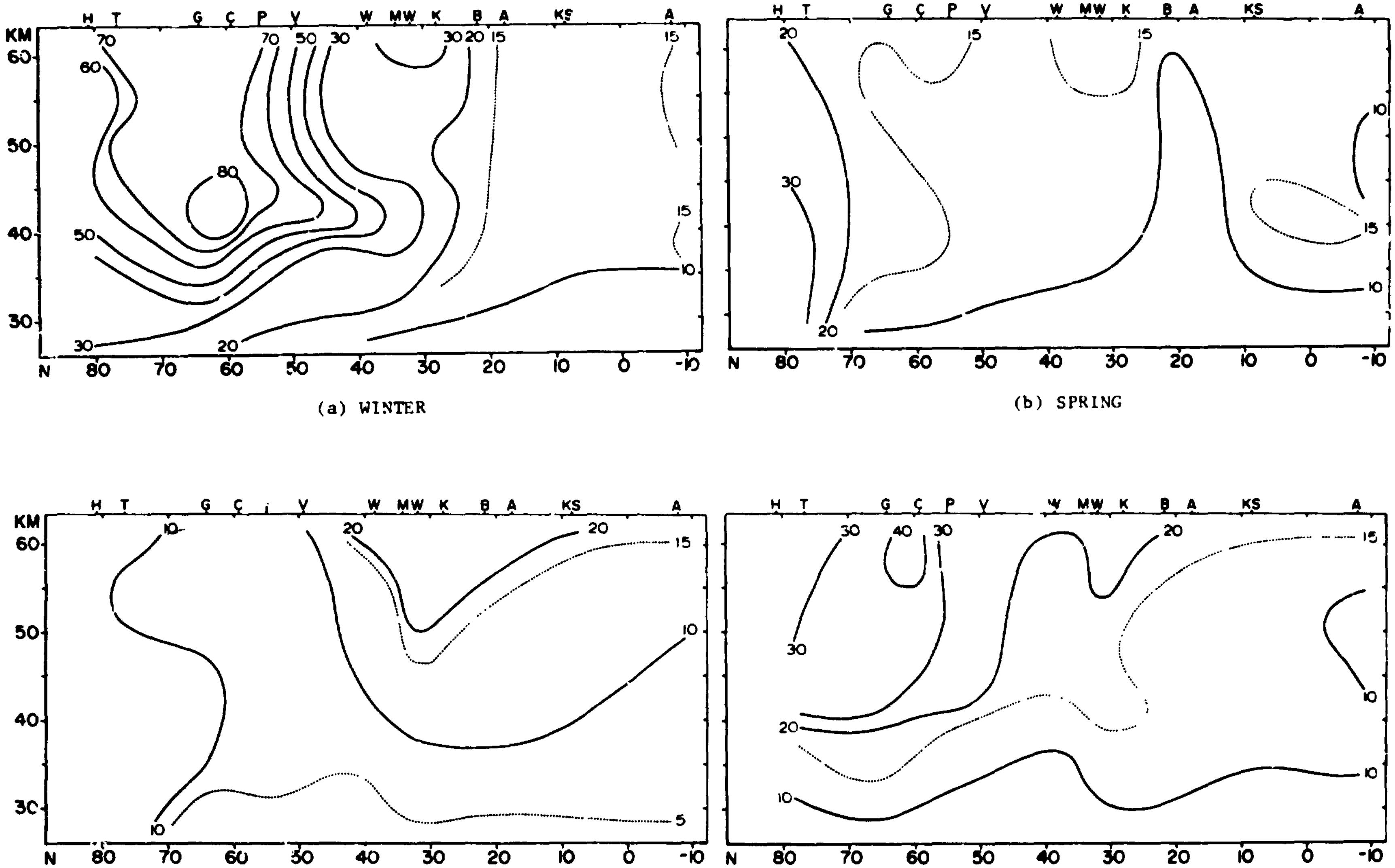



FIGURE 7. Seasonal mean temperatures ($^{o}$K).




(a) WINTER

(b) SPRING

(c) SUMMER

(d) AUTUMN

FIGURE 8. Variance of temperature ($^{o}K^{2}$).

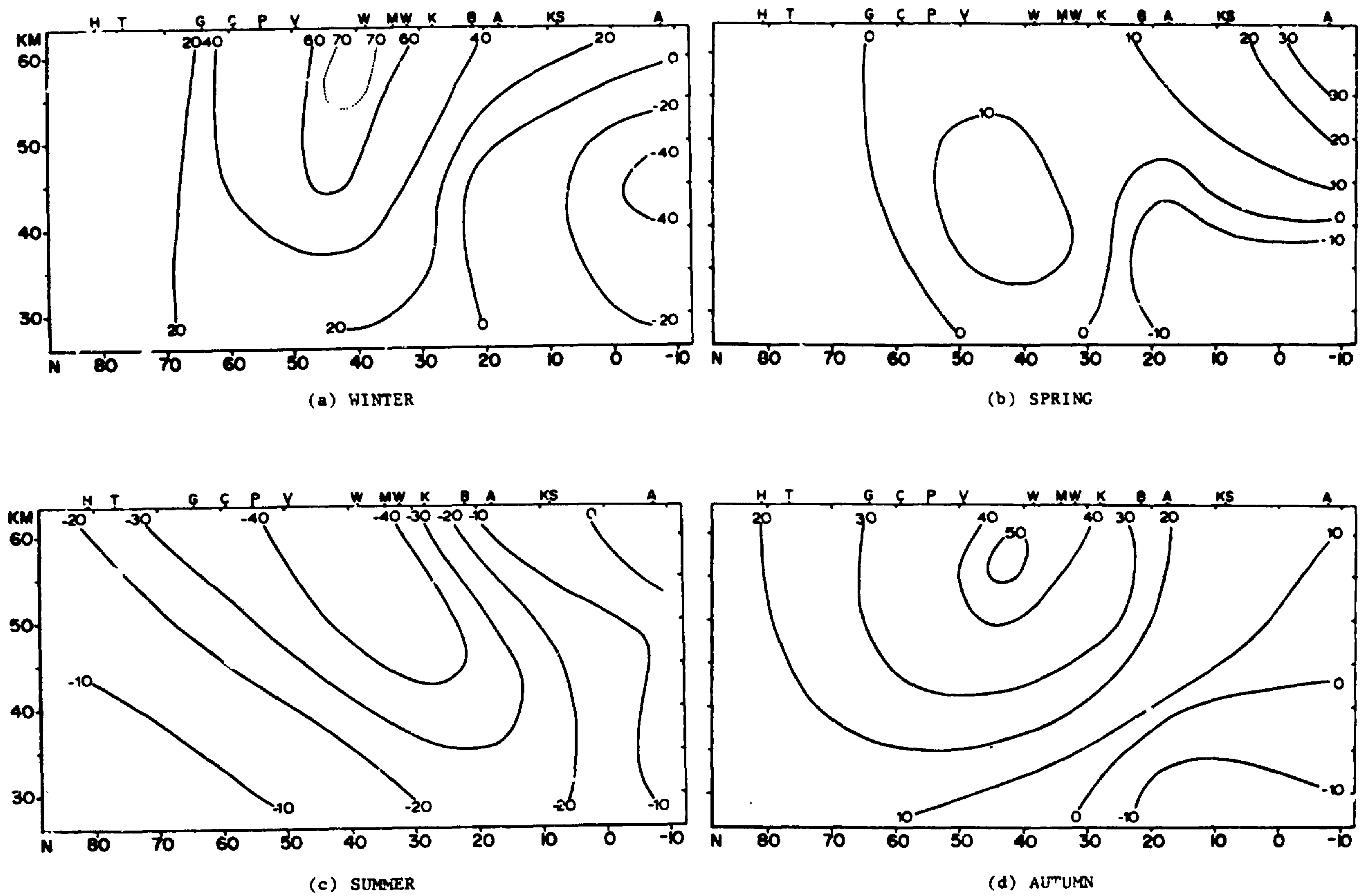
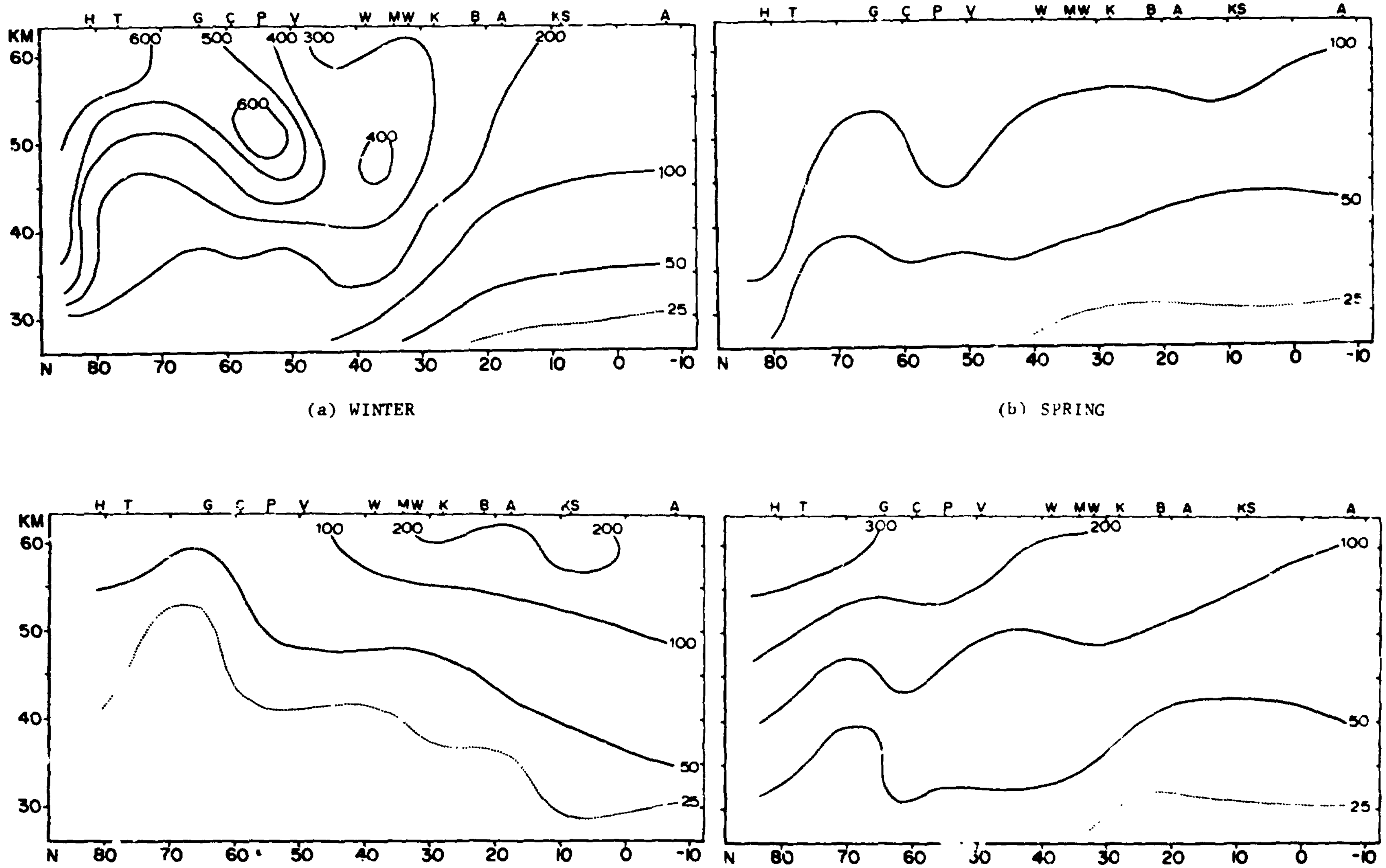


FIGURE 9. Seasonal mean zonal wind speed (m $sec^{-1}$).




(a) WINTER (b) SPRING

(c) SUMMER (d) AUTUMN

FIGURE 10. Variance of zonal wind speed ($m^2$ $sec^{-2}$).

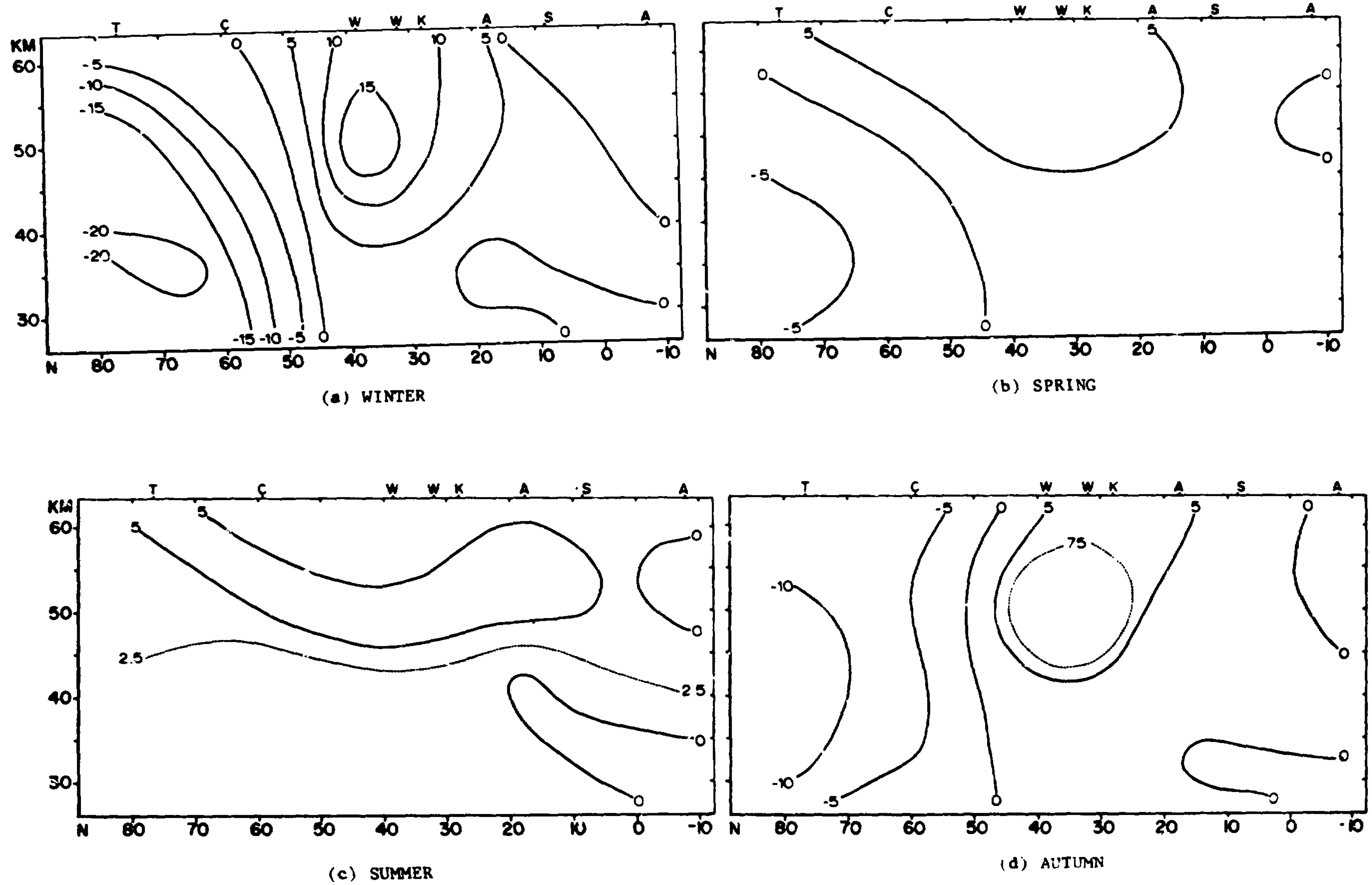
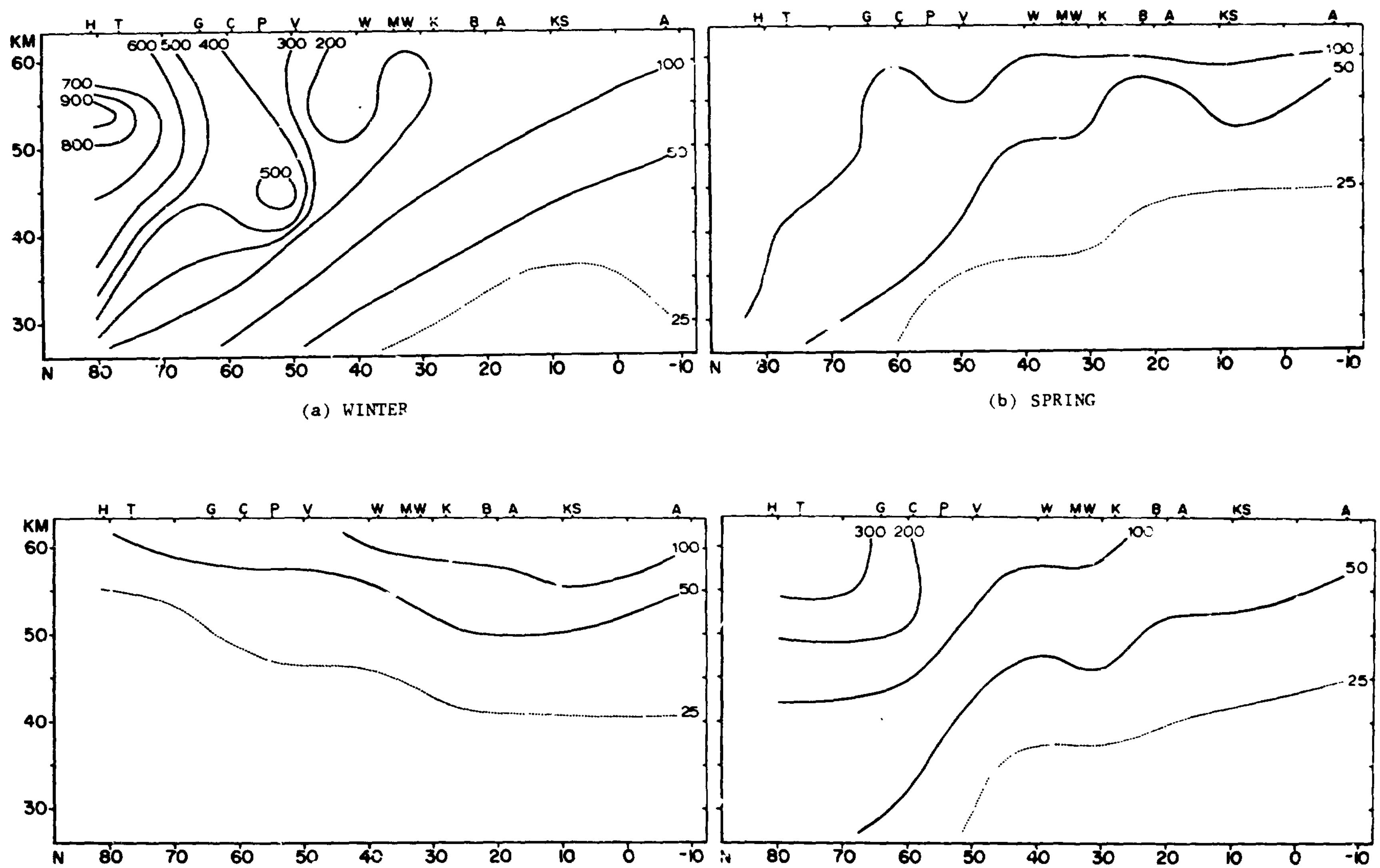



FIGURE 11. Sea- nal mean meridional wind speed (m $sec^{-1}$) along $80^{o}$W.




(a) WINTER

(b) SPRING

(c) SUMMER

(d) AUTUMN

FIGURE 12. Variance of meridional wind speed ($m^2 sec^{-2}$).

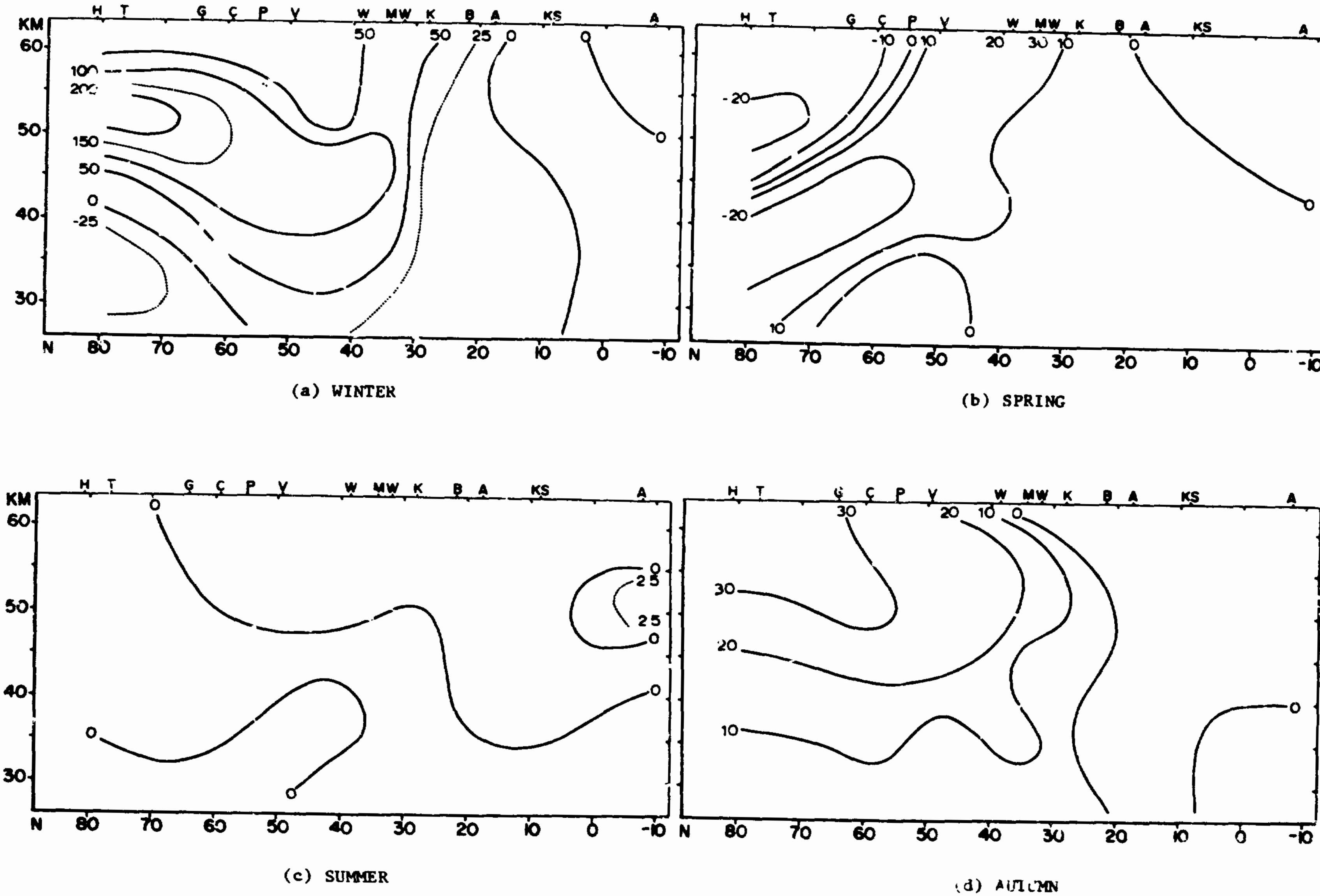
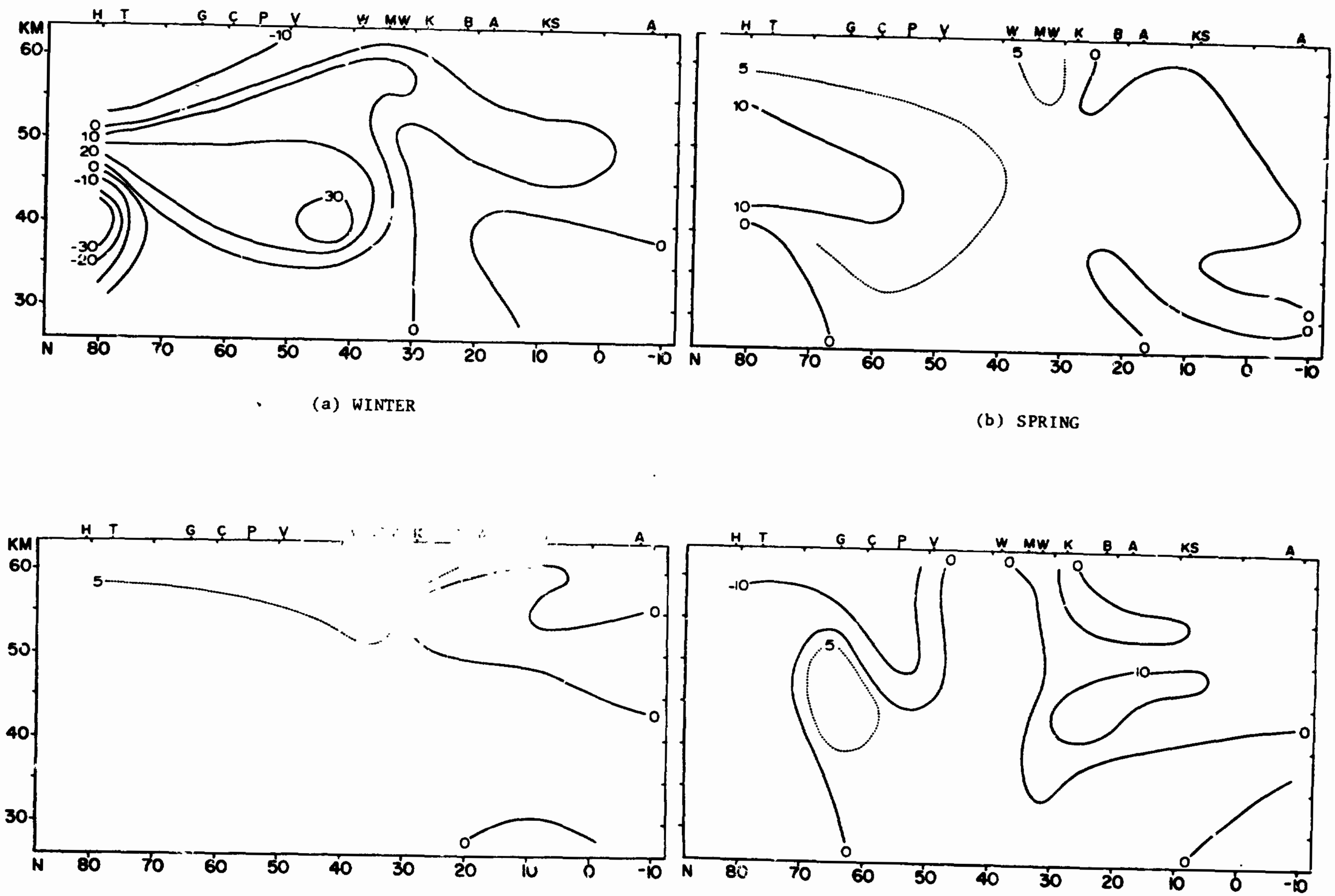



FIGURE 13. Covariance of zonal and meridional wind speed ($m^2\ sec^{-2}$).



(a) WINTER

(b) SPRING

(c) SUMMER

(d) AUTUMN

FIGURE 14. Covariance of temperature and meridional wind speed ($m\,K\,sec^{-1}$).